THE MUNICIPAL UNIVERSITY OF WICHITA

PERFORMANCE TEST OF A SIDE-INLET, STEAM-TO-AIR JET PUMP WITH AN INBOARD NOZZLE AND A TAPERED MIXING TUBE

by A. M. Heinrich

Engineering Report No. 138

for the Office of Naval Research
Contract N-onr 201(01)

May 1954
University of Wichita
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TABLE OF CONTENTS

	Page
LIST OF FIGURES	ii
SUMMARY	1
INTRODUCTION	2
SYMBOLS AND SUBSCRIPTS	2
TESTS	3
APPARATUS	3
PERFORMANCE ANALYSIS	4
RESULTS AND DISCUSSION	5
CONCLUSIONS	6
REFERENCES	6
APPENDIX - Test Log of SISA-3 Jet Pump	7
TABLE - SISA-3 Jet-Pump Performance	10
FIGURES	11

LIST OF FIGURES

Figure		Page
1.-	Planform outline; side-inlet, steam-to-air jet pump.	11
2.-	Cross section of SISA-3 jet-pump at diffuser entrance.	12
3.-	Cross section of SISA-3 jet-pump at nozzle exit.	13
4.-	Arrangement of the mixing and blowing tubes.	14
5.-	Arrangement of mixing-tube pressure taps and throat adjustment bolts.	14
6.-	Suction slot with static pressure taps.	15
7.-	View of the jet pump looking through the suction slot and duct into the cascaded mixing-tube throat.	15
8.-	Instrumentation schematic.	16
9.-	Variation of pressure ratio with mass ratio.	17
10.-	Variation of efficiency with mass ratio.	18
11.-	Variation of efficiency with pressure ratio.	19
12.-	Distribution of available energy efficiency.	20
13.-	Variation of suction-duct total-pressure loss with flow quantity.	22
14.-	Influence of cascades, jet total pressure, and pressure ratio on suction-slot quantity distribution.	23
15.-	Suction duct flow pattern.	30
16.-	Mixing-tube entrance throat widths.	31
17.-	Influence of cascades, jet total pressure, and pressure ratio on throat static pressure distribution.	32
18.-	Influence of cascades, jet total pressure, and pressure ratio on mixing-tube static-pressure distribution.	38
19.-	Influence of jet total pressure and pressure ratio on mixing-tube total-pressure distribution.	45
20.-	Influence of jet total pressure and pressure ratio on temperature distribution.	61

SUMMARY

A series of tests were conducted to determine the performance, the pressure and temperature distributions, and the nature of the flow in a side-inlet jet-pump with an inboard nozzle. This series of tests were performed on a pump having a conical mixing tube, a cascaded side-entrance throat, a suction duct, and a suction slot of constant width.

The effects of varying the primary jet pressure, the pump pressure ratio, and the cascades were determined. Pump pressure ratio was varied both with and without control of the suction-slot flow distribution. Flow direction in the suction duct between the slot and the throat was studied with the aid of wool tufts.

Performance curves are presented together with curves showing mixing-tube, cross-sectional distributions of temperature and total pressure taken at several survey stations. This report is the second in a series on side-inlet jet pumps with different taper ratio mixing tubes.

INTRODUCTION

The side-inlet steam-to-air jet pump provides a simply constructed and compact air pump to fulfill the requirements of a high-speed aircraft system of wing circulation control. As a continuance of the experimental analysis of side-inlet steam-to-air jet pumps, a conical mixing-tube pump was tested.

The purpose of this report was to organize the data and present the test results in a manner usable for a comparative evaluation with previous jet pump tests by the University of Wichita. The design, construction and tests of the jet pump were performed by the University of Wichita, School of Engineering under the authority of Contract N-onr 201(01) from the Air Branch of the Office of Naval Research.

SYMBOLS

D	diameter of mixing tube or throttling orifices, inches
ρ	density, slugs/ft^3
h	enthalpy, BTU/lb
t	temperature, °F
p_t	total pressure, lb/ft^2
p	static pressure, lb/ft^2
P	power, ft-lb/sec
J	mechanical equivalent of heat, 778 ft-lb/BTU
V	velocity, ft/sec
v	local velocity, ft/sec
q	volumetric flow rate, ft^3/sec
w	weight flow rate, lb/sec
α	pressure ratio = p_{t_3}/p_{t_0}
μ	mass ratio = w_s/w_j
η	efficiency = P_{eff}/P_{in}

Subscripts

0	free-stream or ambient conditions
1	suction-slot conditions
2	mixing-tube-entrance throat conditions
3	mixing-tube exit conditions
AE	available energy

j primary or jet flow

s secondary flow

m mixture of primary and secondary flow

x axial position from the inboard end of mixing tube

in input

eff effective

TESTS

The testing and data recording were in accordance with the pre-test report (Reference 1). Throat adjustments were made to give maximum secondary-air mass flow with a desirable suction-slot flow-quantity distribution. All tests were run with a constant suction-slot width.

The following measurements were taken:

1.- Suction-slot area.
2.- Suction-slot static pressure distribution.
3.- Suction-slot air temperature.
4.- Mixing-tube-entrance throat area.
5.- Mixing-tube-entrance throat static pressure distribution.
6.- Mixing-tube-entrance throat air temperature.
7.- Mixing-tube static-pressure distribution.
8.- Mixing-tube cross-sectional, total-pressure distribution.
9.- Mixing-tube cross-sectional, temperature distribution.
10.- Steam temperature.
11.- Steam total pressure.
12.- Barometric pressure.
13.- Mixing-tube exit:
Variation of the jet-pump throttling by successive steps from an open exit to a condition of slight reverse flow in the suction slot.

APPARATUS

Figures 1 through 5 show the layout and the side-inlet jet pump construction. The inlet duct, cascades, mixing tube, and blowing tube were fabricated from sheet metal. The suction slot and supporting framework were made of wood and angle iron. Entrance points for the primary and secondary streams and their flow through the jet pump are shown schematically in figures 1, 2, and 3.

The model variables consisted of the mixing-tube entrance throat width and blowing-tube exit throttling. Variation of the primary steam flow total pressure and temperature was obtained through control of the steam generator-superheater system described in reference 2. Manometers and probes used in the tests are shown in figure 7 and also in reference 2.

PERFORMANCE ANALYSIS

The jet-pump performance parameters were detailed in the pre-test report (Ref. 1) and in Reference 2. An attempt was made to determine the influence of specific impulse on performance. The results of this attempt were, however, considered invalid since irregular mixing tube static pressure distribution occurred. The irregularities were presumably a result of off-design expansion characteristics of the nozzles used to obtain the variation in specific impulse. Total pressure losses in the suction duct were determined from average velocities and pressures found by integrating the flow quantity distribution curves.

The approximate total-pressure losses in the suction duct were determined from the relation

$$p_t = p_{t_1} - p_{t_2} = p_{t_0} - \left[(p_{t_0} + p_2) + \frac{1}{2}\rho_2 V_2^2\right]$$
$$= -p_2 - \frac{1}{2}\rho_2 V_2^2.$$

The effective power output, the power input, and the efficiency were determined from the following relations from reference 1.

$$P_{eff} = q_s (p_{t_3} - p_{t_1}) + q_j (p_{t_3} - p_{t_0})$$

$$P_{in} = w_j \Delta h J$$

$$\eta = \frac{P_{eff}}{P_{in}}$$

The mass ratio was expressed by the secondary to primary weight flow ratio,

$$\mu = w_s/w_j.$$

Jet-pump pressure ratio was defined as the ratio of the mixed-flow total pressure, at the final plane, to the ambient total pressure

$$\alpha = p_{t_3}/p_{t_0}.$$

The available energy efficiency at any point in the mixing tube was the ratio of the local available energy of the mixture to the available energy of the primary flow at the nozzle and was expressed by the following relation of the kinetic and pressure energies.

$$\eta_{AE_x} = \frac{\frac{1}{2}\rho_{m_x} V_{m_x}^2 + p_{m_x}}{\frac{1}{2}\rho_j V_j^2}$$

RESULTS AND DISCUSSION

Figures 9 through 11 show a performance summary of the side-inlet stream-to-air jet pump having a tapered mixing tube. For the tests with uncontrolled suction-slot quantity distribution the pressure ratio varied linearly as a function of the higher mass ratios. This linearity, however, existed only to the point of incipient reverse flow in the suction duct. As the reverse flow spread through the suction duct and slot the performance curve departed appreciably from the linear relationship. The tests with the suction-slot flow quantity controlled for distribution show a lower maximum pressure ratio, a more rapid deteriation of performance after suction-slot reverse flow appeared, but exhibited a better performance in the region of high mass ratios and low pressure ratios.

Figure 12 shows the distribution of the available energy. Usable energy was available through the mixing tube almost to the diffuser entrance. The location at which the available energy was reduced to less than one percent of the initial value was the same for all the pressure ratios and mass ratios tested.

The variation of suction-duct total-pressure loss with flow quantity is shown in figure 13. The most losses were experienced for the highest pressure ratios. A linear increase of losses resulted from an increase in secondary flow where the pressure ratio and throat width were constant.

Complete cascading of the entrance throat gave a higher mass ratio and better distribution of suction-slot flow than any partial cascade arrangement tested (shown by figure 14). Tuft pictures of the flow within the suction duct (fig. 15) showed the air flow turning upstream of the cascade location in the suction duct. The airflow divided at the juncture of cascades and unobstructed throat.

Figure 16 gives the throat widths required for the slot quantity distribution. Figure 17 shows the effect of cascade arrangement, jet total-pressure variation, and pressure ratio variation on the distribution of static pressure in the mixing - tube throat. Runs 11 through 22 show only the effect of pressure ratio while runs 23 through 29 show combined effects of pressure ratio and slot width.

Variation of the jet total pressure did not appreciably change suction-slot quantity distribution. Throttling the pump sufficiently to cause suction-slot reverse flow progressively decreased the slot flow quantity with the greatest effect occurring in the outboard area. Increase of pressure ratio while maintaining nearly uniform suction-slot quantity distribution resulted in a continual decrease of secondary air flow.

The mixing-tube static-pressure distributions for the various cascade arrangements, jet total pressures, and pressure ratios are shown in figure 18. Figures 19 and 20 show cross-sectional survey data of mixing-tube total pressure and temperature at several stations. Surveys in the inboard portion of the mixing tube showed a low energy secondary flow and a high energy primary flow in their adjacent relative positions. In the portion of the mixing tube approaching the diffuser the mixing-tube flow appeared mixed as indicated by the total pressure profiles, while at the diffuser exit the flow was almost completely mixed. The temperature surveys in the mixing tube supplemented the total-pressure surveys and demonstrated by the low or high temperatures the areas of unmixed secondary and primary flow. Average integrated values of the horizontal and vertical total-pressure profiles combined with the local static pressures were used to approximate the local available energy of the mixing tube flow.

The performance analysis of the SISA-3 steam-to-air jet pump with the side inlet and tapered mixing tube was made to comparatively show the effect of mixing-tube shape. Also, this analysis shows the relative merits of secondary airflow guidance and distribution methods as compared to the cylindrical mixing-tube pump of reference 2.

CONCLUSIONS

The experimental analysis of a side-inlet, steam-to-air jet pump with an inboard nozzle and a conical mixing tube has shown this arrangement to have reasonably low losses for desirable suction slot quantity distribution properties. Suction-slot flow-quantity distribution was easily obtained as a result of the available energy distribution through the mixing tube. Regulation of the available energy distribution was obtained through the diffuser action of the conical mixing tube.

A comparative evaluation of the presented data with the data for the cylindrical mixing tube of reference 2 should provide sufficient information to formulate a design procedure for the side-inlet steam driven jet pump. Further tests should be conducted to produce any specific design to reduce the losses to a minimum.

REFERENCES

1.- Heinrich, A.M.: Pre-test Report on the Performance Study of a Side-Inlet Jet-Pump with an Inboard Nozzle. University of Wichita Engineering Study No. 117, October 1953.

2.- Heinrich, A.M.: Performance Test of a Side-Inlet, Steam-to-Air Jet Pump with an Inboard Nozzle. University of Wichita Engineering Report No. 131, February 1954.

APPENDIX

TEST LOG OF SISA-3 JET PUMP

Runs SISA-3-1 through SISA-3-29

TEST LOG, SISA-3 JET PUMP

Run No.	Configuration	Remarks
1 thru 5	Constant slot width with throat adjusted for slot quantity distribution in run no. 1 only. Cascade configuration as follows: Run 1 - all cascades. Run 2 - 36 inches of cascades inboard. Run 3 - 24 inches of cascades inboard. Run 4 - 12 inches of cascades inboard. Run 5 - without cascades.	These five runs were made to determine the influence of the mixing-tube cascades on performance and on suction-slot quantity distribution. Test results showed the configuration with all cascades to be the most desirable.
6 thru 10	Constant slot width with the throat adjusted to give maximum secondary flow and desired suction-slot distribution. The jet total pressure was varied as follows: Run 6 - p_{t_j} = 344.2 psia Run 7 - p_{t_j} = 314.2 psia Run 8 - p_{t_j} = 287.2 psia Run 9 - p_{t_j} = 262.2 psia Run 10- p_{t_j} = 237.2 psia	These five runs were made to determine the influence of the primary-jet total pressure on the performance. The static-pressure distribution of the throat and mixing tube were measured.
11 thru 20	Constant slot width with the throat adjusted for best secondary-flow quantity distribution in the open-exit configuration. This throat was maintained for runs 11 thru 20. Throttled as follows: Run 11 - D_4/D_3 = 1.0 Run 12 - " = 0.942 Run 13 - " = 0.906 Run 14 - " = 0.857 Run 15 - " = 0.823 Run 16 - " = 0.792 Run 17 - " = 0.765 Run 18 - " = 0.723 Run 19 - " = 0.673 Run 20 - " = 0.622	These ten runs were made to determine the effects of increased pressure ratio on mass ratio, secondary-flow quantity distribution and throat and mixing tube static-pressure distributions.

Run No.	Configuration	Remarks
21 and 22	Constant slot width with the throat adjusted for best secondary flow quantity distribution in unthrottled configuration. Throttled as follows: Run 21 - D_4/D_3 = 1.0 Run 22 - " = 0.765	These two runs were made to determine the nature of the mixing-tube flow at two values of pressure ratio. The secondary flow was not controlled for quantity distribution.
23 thru 27	Constant slot width with the throat adjusted to give desired secondary flow quantity distribution for each run. Throttled as follows: Run 23 - D_4/D_3 = 1.0 Run 24 - " = 0.906 Run 25 - " = 0.823 Run 26 - " = 0.765 Run 27 - " = 0.723	These five runs were made to determine the performance and the effects of pressure ratio on mass ratio with the secondary flow evenly distributed along the suction slot.
28 and 29	Constant slot width with the throat adjusted to give desired secondary flow quantity distribution for each run. Throttled as follows: Run 28 - D_4/D_3 = 0.792 Run 29 - " = 0.857	These two runs were made to supplement the data of runs 23 to 27, and to determine the nature of the mixing-tube flow at two values of pressure ratio.

TABLE - SISA-3 Jet Pump Performance

Run No.	P_{tj} (psia)	t_j (°F)	w_s (lb/sec)	w_j (lb/sec)	$\mu = \frac{w_s}{w_j}$	$\alpha = \frac{P_{t3}}{P_{t0}}$	η
1	304.3	660	2.56	0.232	11.03		
2	304.3	660	2.45	0.232	10.56		
3	304.3	660	2.44	0.232	10.52		
4	304.3	660	2.31	0.232	9.96		
5	304.3	660	2.23	0.232	9.61		
6	344.2	658	2.68	0.26	10.3	1.013	2.405
7	314.2	662	2.61	0.239	10.9	1.013	2.48
8	287.2	645	2.54	0.218	11.65	1.012	2.46
9	262.2	660	2.415	0.201	12.0	1.011	2.40
10	237.2	650	2.33	0.182	12.8	1.01	2.31
11	298.08	653	2.505	0.224	11.18	1.013	2.295
12	298.07	653	2.403	0.224	10.72	1.017	3.24
13	298.07	651	2.320	0.2236	10.38	1.021	3.97
14	298.07	652	2.19	0.2238	9.79	1.025	4.64
15	297.07	653	2.07	0.223	9.28	1.03	5.20
16	297.07	653	1.98	0.223	8.88	1.034	5.63
17	297.06	655	1.855	0.2233	8.81	1.039	6.20
18	297.06	654	1.765	0.2231	7.91	1.043	6.49
19	299.10	658	1.538	0.225	6.83	1.05	7.16
20	299.10	660	1.362	0.2255	6.04	1.053	7.39
21	298	652	2.415	0.224	10.8	1.012	4.28
22	297.3	652	1.84	0.2235	8.23	1.04	6.15
23	296.65	657	2.58	0.2330	11.55	1.01	2.495
24	296.65	654	2.48	0.2225	11.13	1.022	4.52
25	296.65	653	2.085	0.2224	9.37	1.03	5.40
26	297.15	653	1.071	0.2224	4.81	1.02	2.24
27	296.65	650	0.686	0.221	3.08	1.014	1.20
28	296.95	657	1.562	0.223	7.00	1.0265	3.67
29	297.02	653	2.235	0.2235	10.00	1.03	5.38

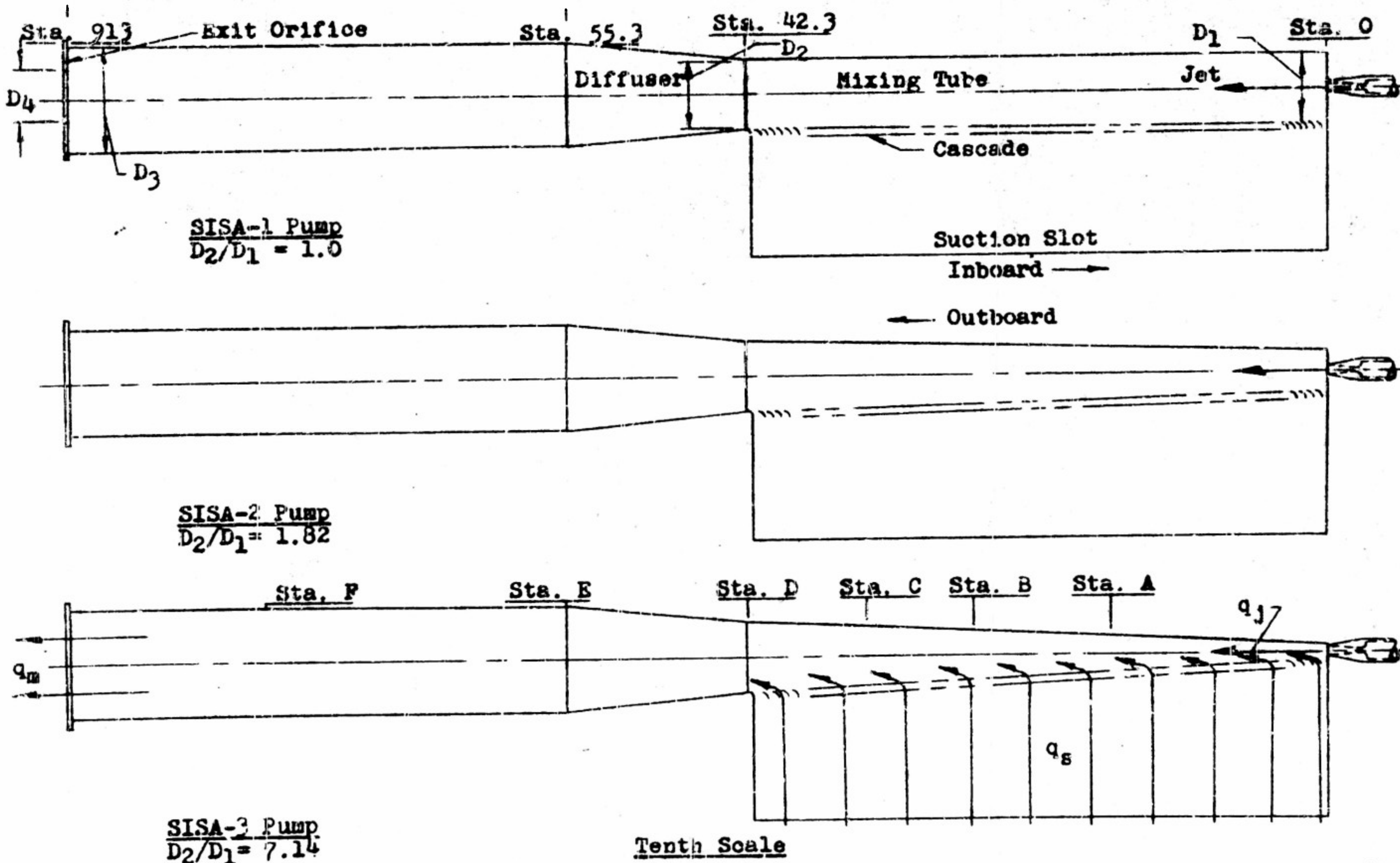


Figure 1.- Planform outline; side-inlet, steam-to-air jet pump.

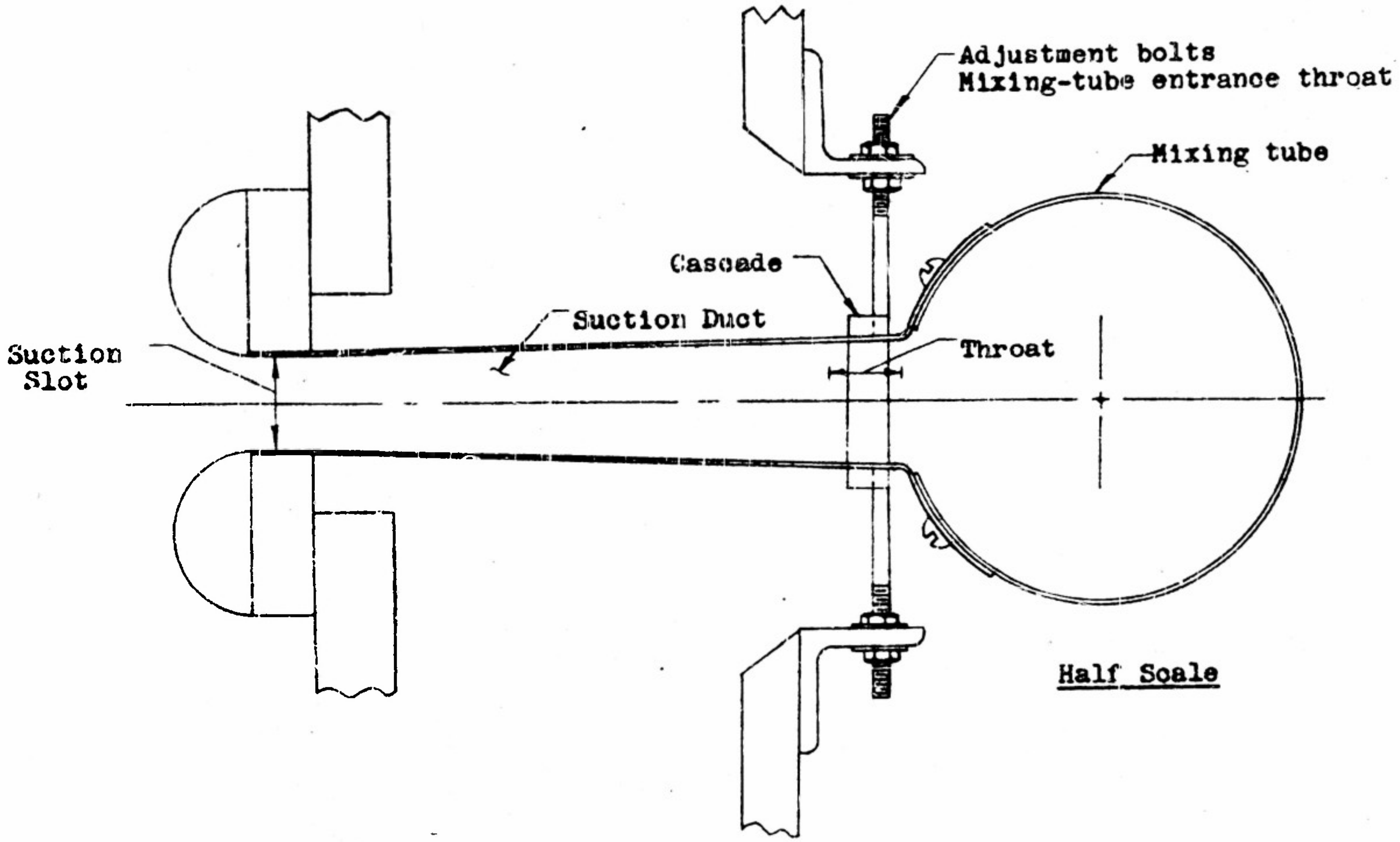


Figure 2.- Cross section of SISA-3 jet-pump at diffuser entrance.

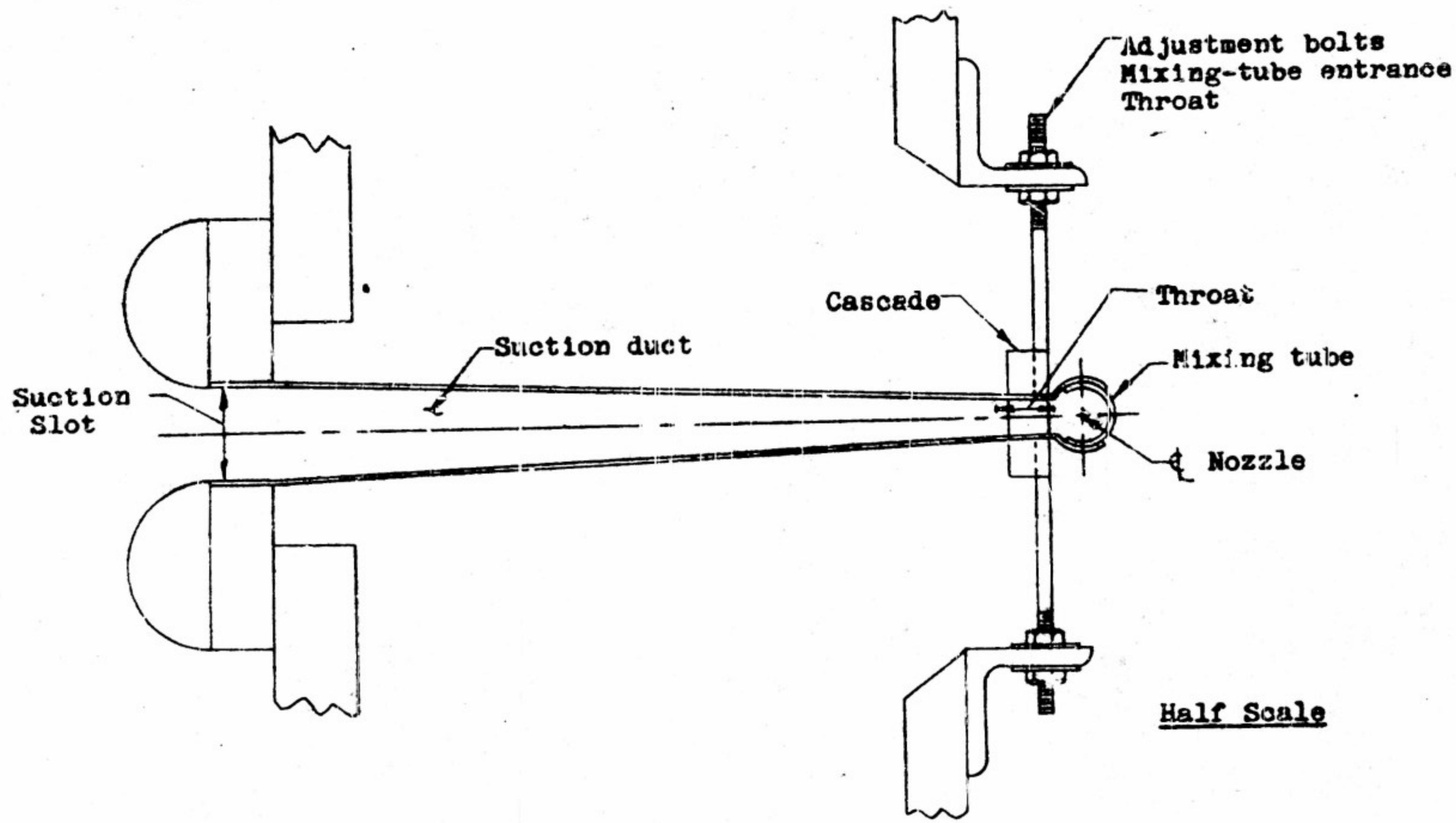


Figure 3.- Cross-section of SISA-3 jet-pump at nozzle exit.

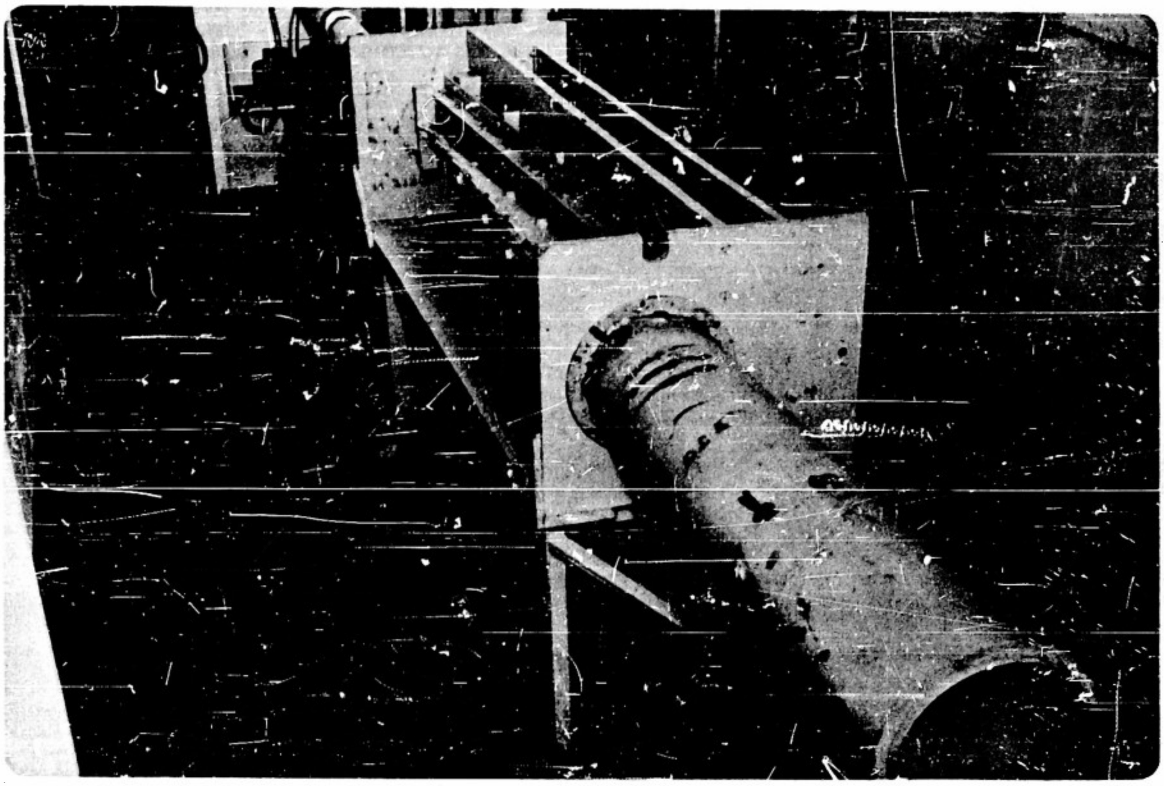


Figure 4.- Arrangement of the mixing and blowing tubes

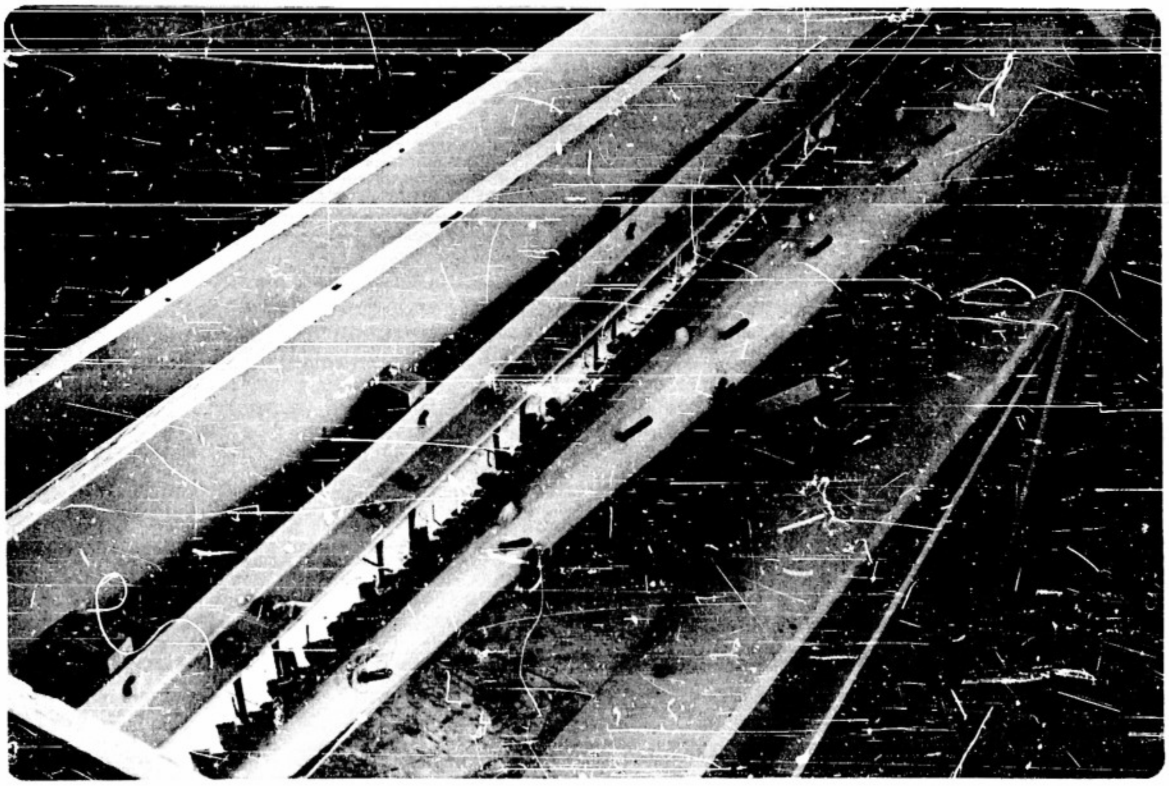


Figure 5.- Arrangement of mixing-tube pressure taps and throat adjustment bolts

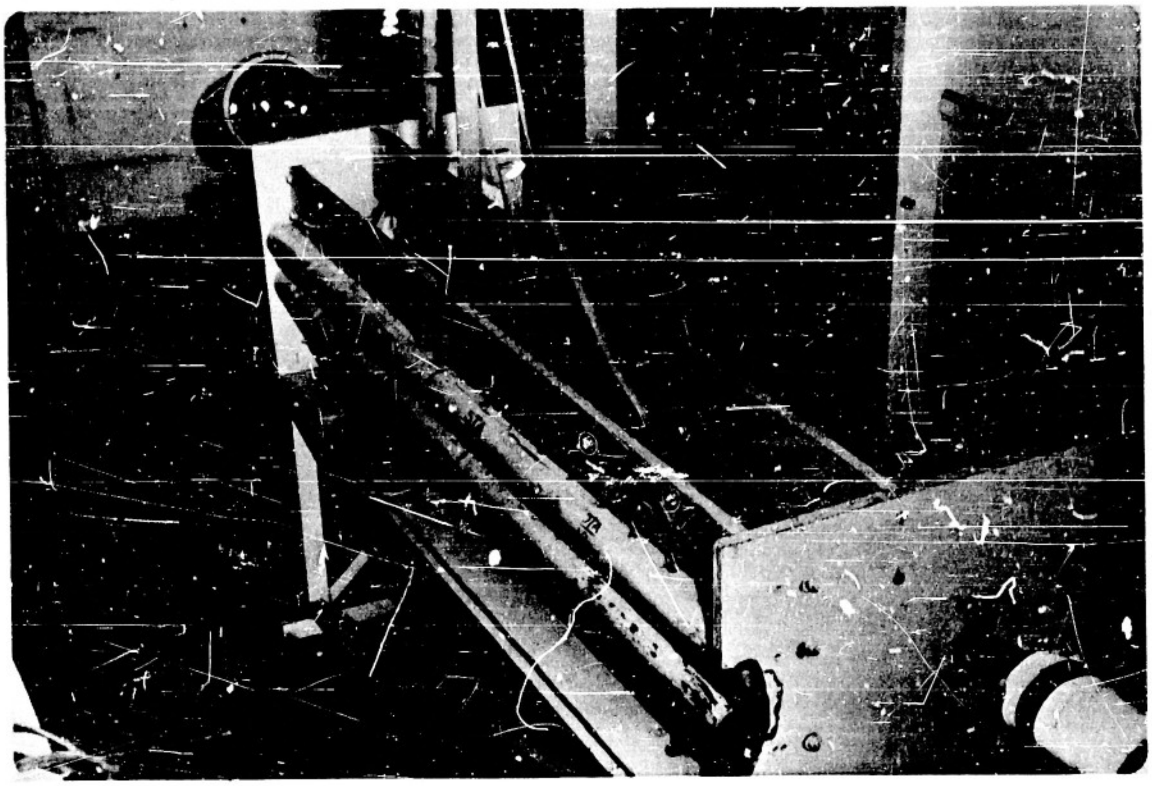


Figure 6.- Suction slot with static pressure taps.

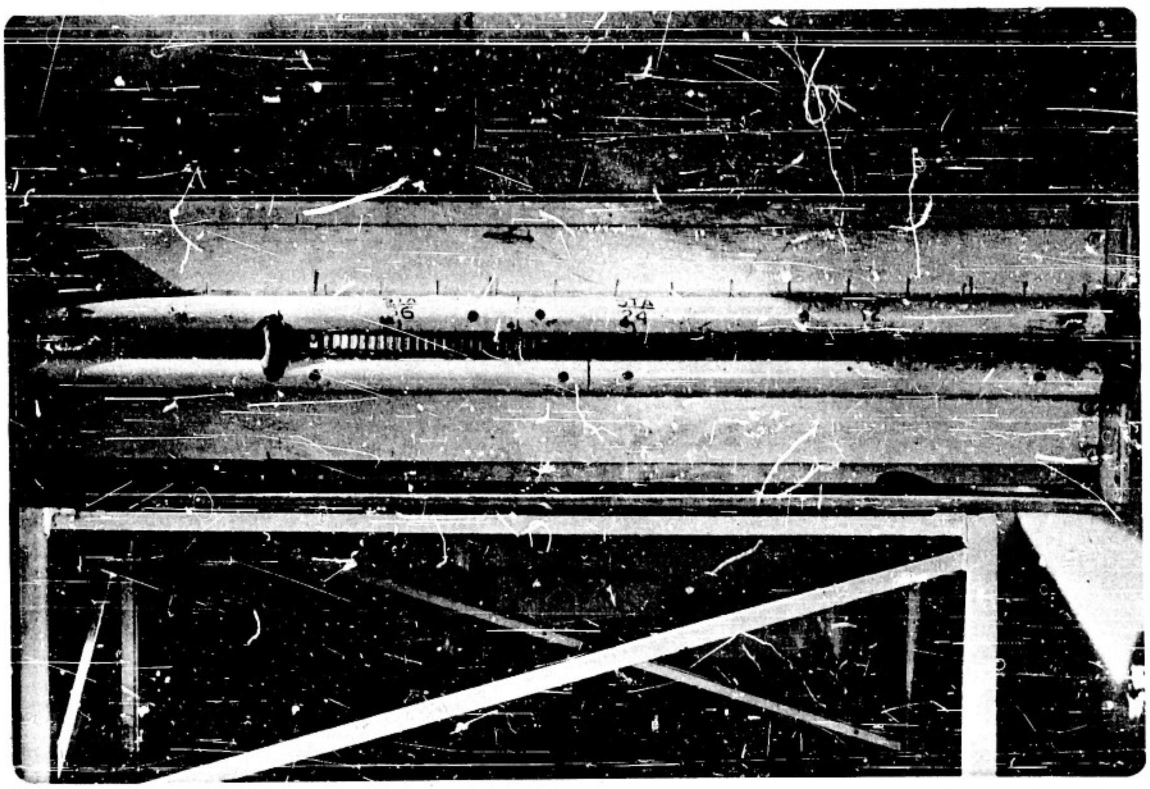


Figure 7.- View of the jet pump looking through the suction slot and duct into the cascaded mixing-tube throat.

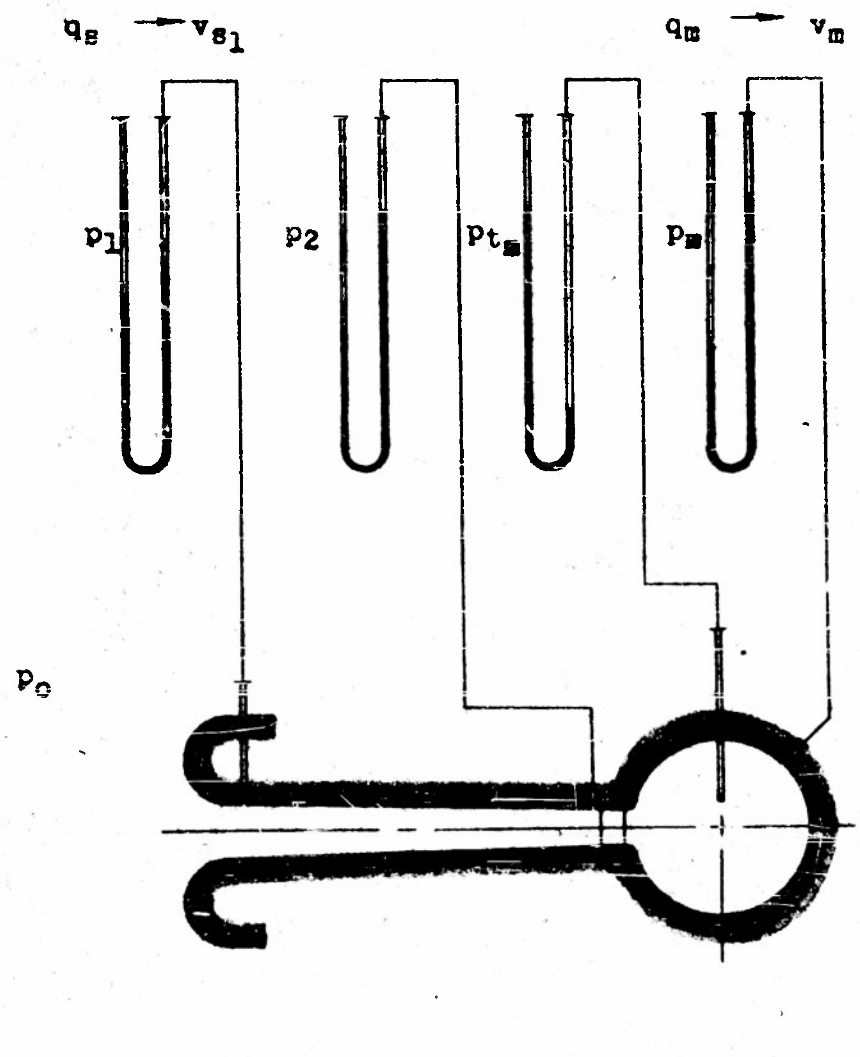
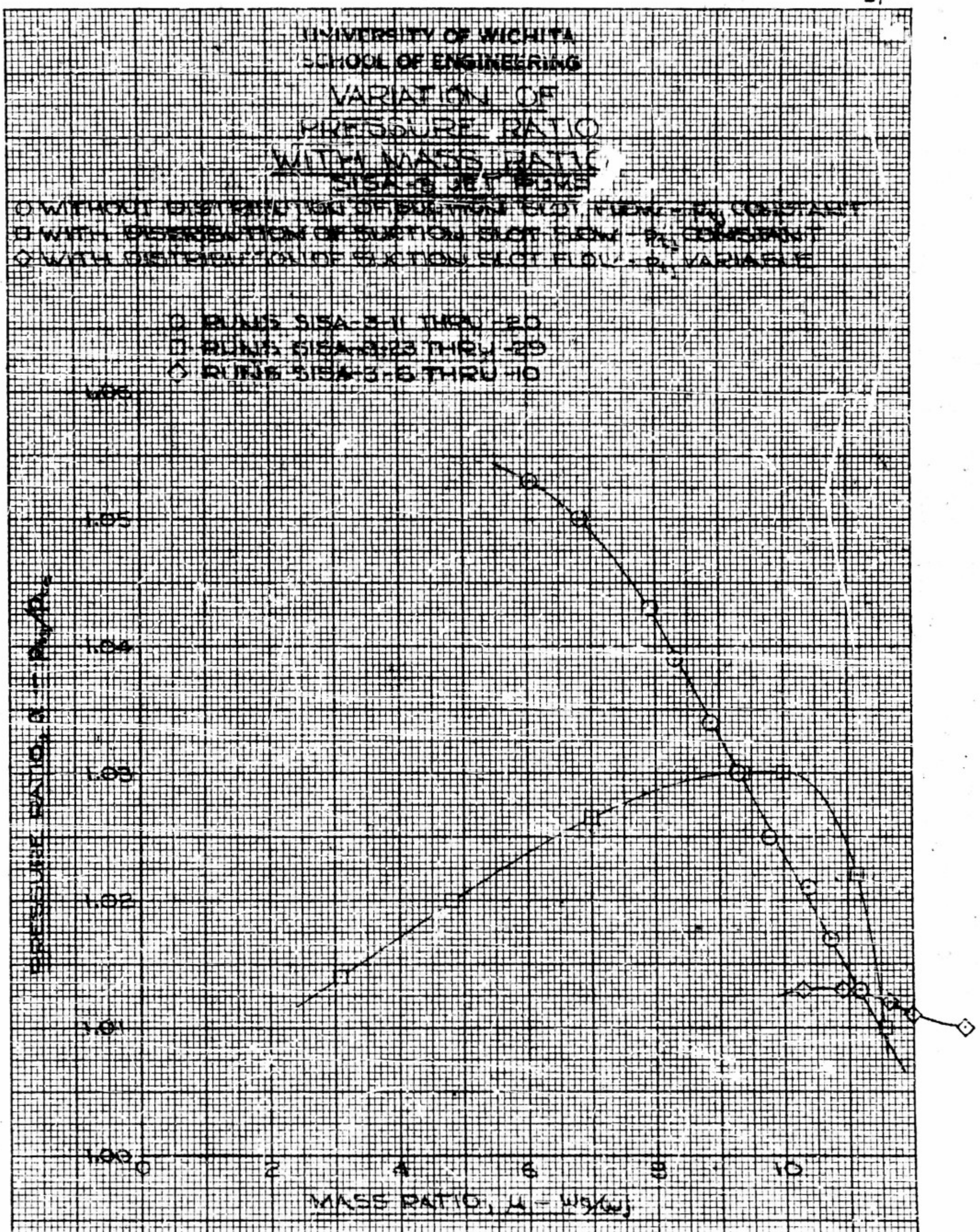


Figure 8.- Instrumentation schematic.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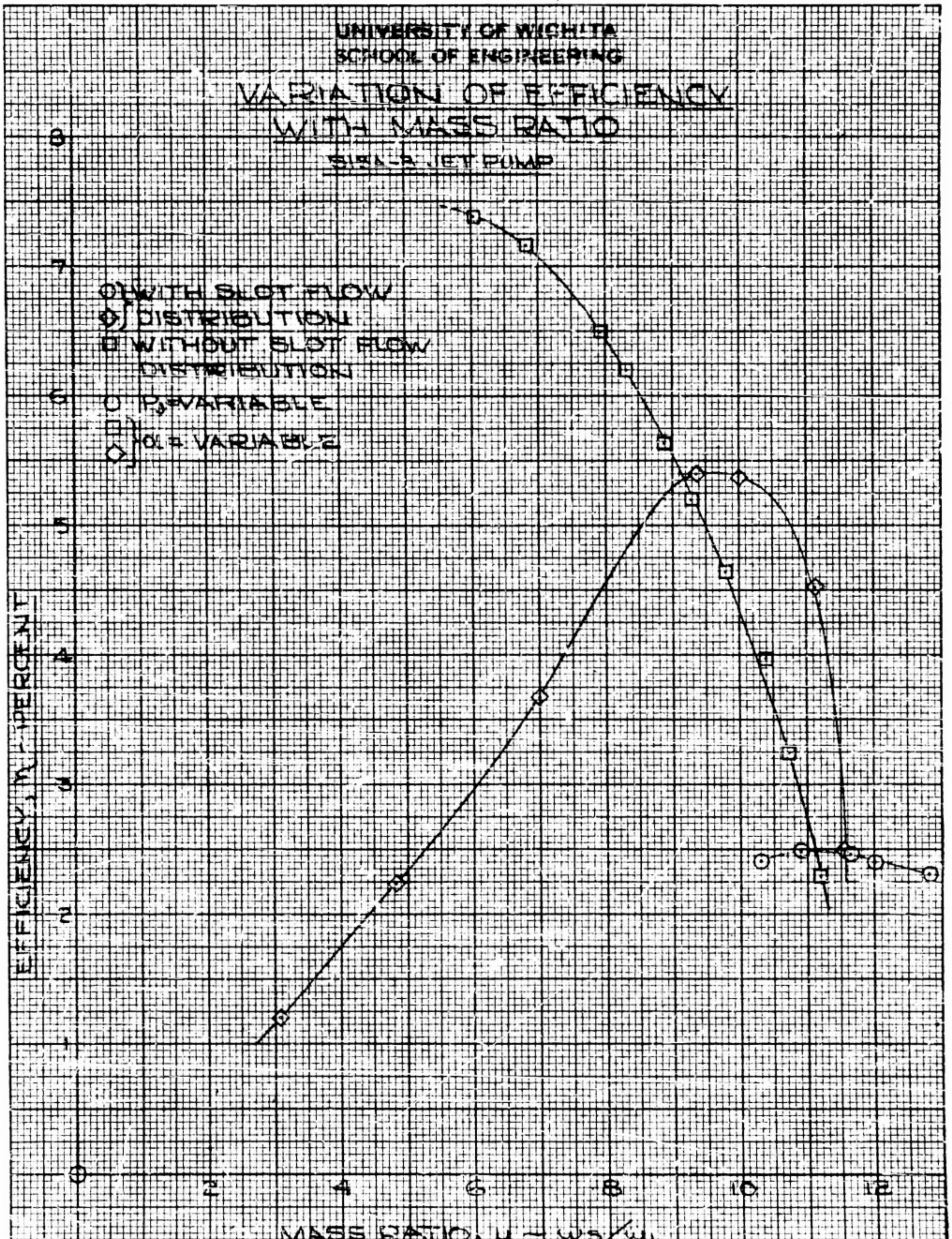
VARIATION OF
PRESSURE RATIO
WITH MASS RATIO
RUNS 515A-3-11 THRU -20
RUNS 515A-3-23 THRU -29
RUNS 515A-3-6 THRU -10
1.06
1.05
1.04
1.03
1.02
1.01
1.00
0
2
4
6
8
10
MASS RATIO, μ = Ws/Wj
PRESSURE RATIO

FIGURE 9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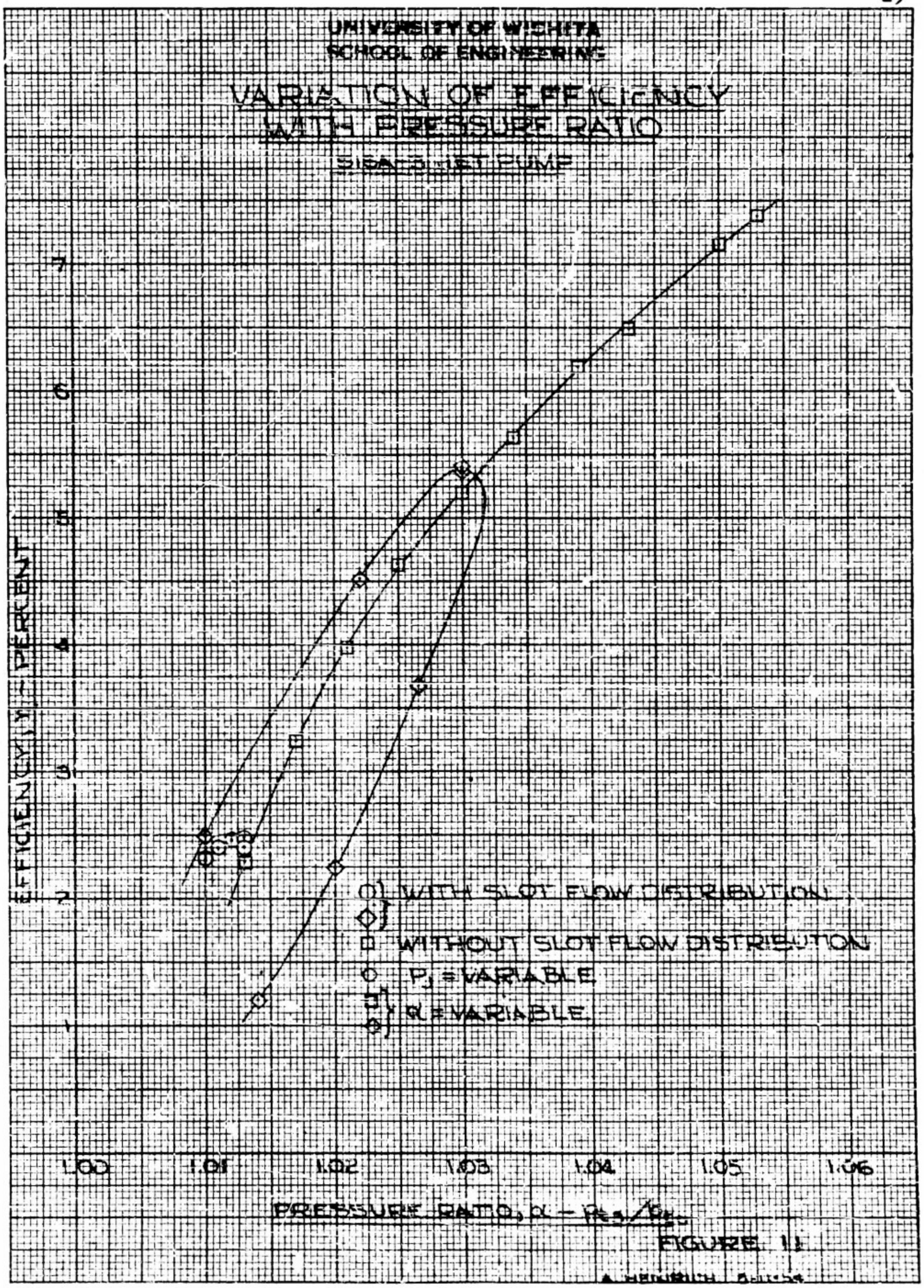
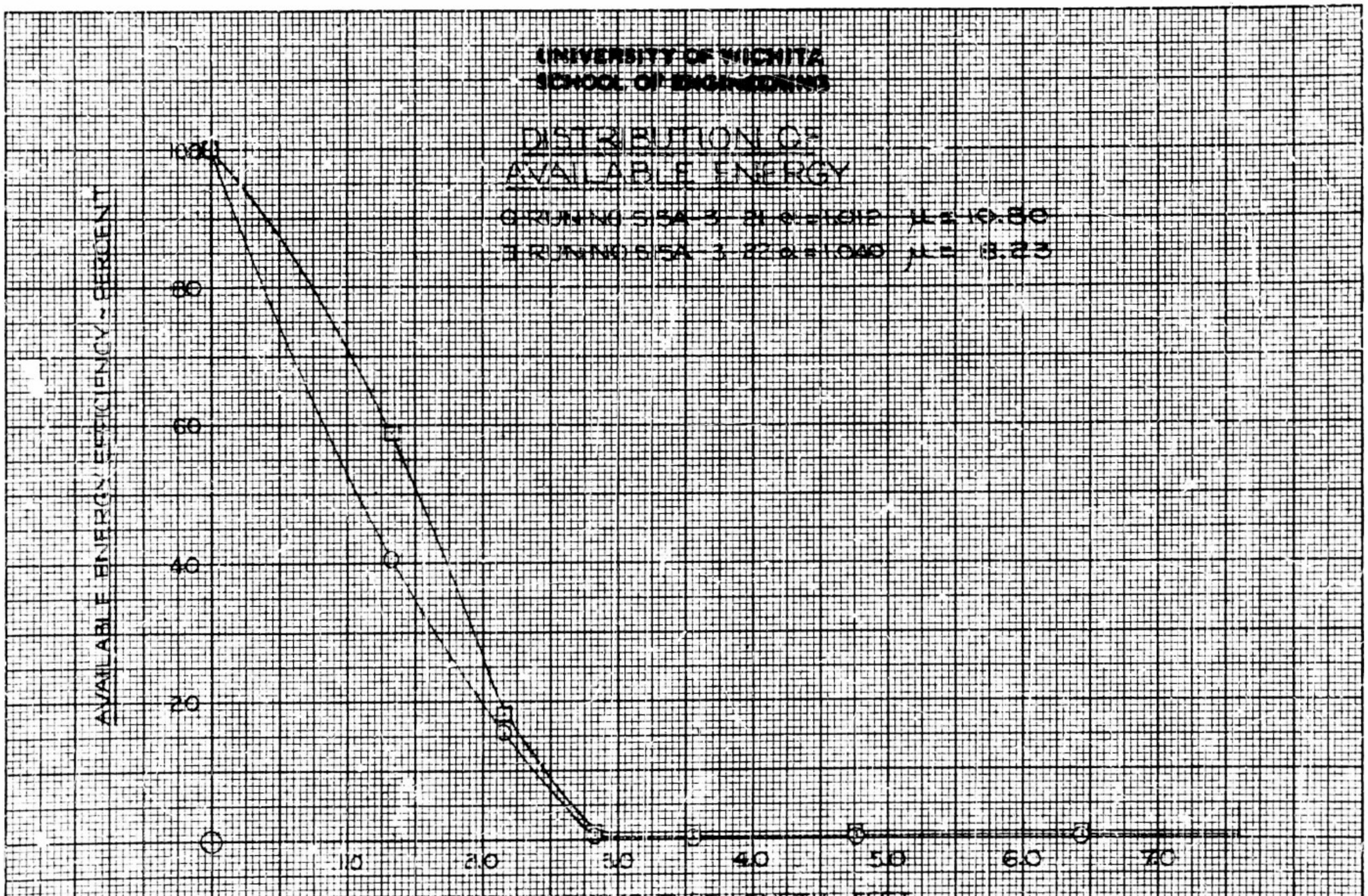
SCHOOL OF ENGINEERING
VARIATION OF EFFICIENCY WITH MASS RATIO
JET PUMP
WITH SLOT FLOW DISTRIBUTION
WITHOUT SLOT FLOW DISTRIBUTION
P VARIABLE
α = VARIABLE
EFFICIENCY, η - PERCENT
MASS RATIO, μ = ws/w
1
2
3
4
5
6
7
8
2
4
6
8
10
12

FIGURE 10


UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING
VARIATION OF EFFICIENCY
WITH PRESSURE RATIO
EFFICIENCY, η - PERCENT
7
6
5
4
3
2
1
WITH SLOT FLOW DISTRIBUTION
WITHOUT SLOT FLOW DISTRIBUTION
P_j = VARIABLE
Q = VARIABLE
1.00
1.01
1.02
1.03
1.04
1.05
1.06
PRESSURE RATIO, α
FIGURE 11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SCHOOL OF ENGINEERING
DISTRIBUTION OF
AVAILABLE ENERGY
RUNNING 5 SA-3 21 α = 1.012 μ = 10.80
RUNNING 5 SA-3 22 α = 1.040 μ = 8.23
AVAILABLE ENERGY EFFICIENCY ~ PERCENT
100
80
60
40
20
1.0
2.0
3.0
4.0
5.0
6.0
7.0
MIXING TUBE LENGTH ~ FEET

FIGURE 12

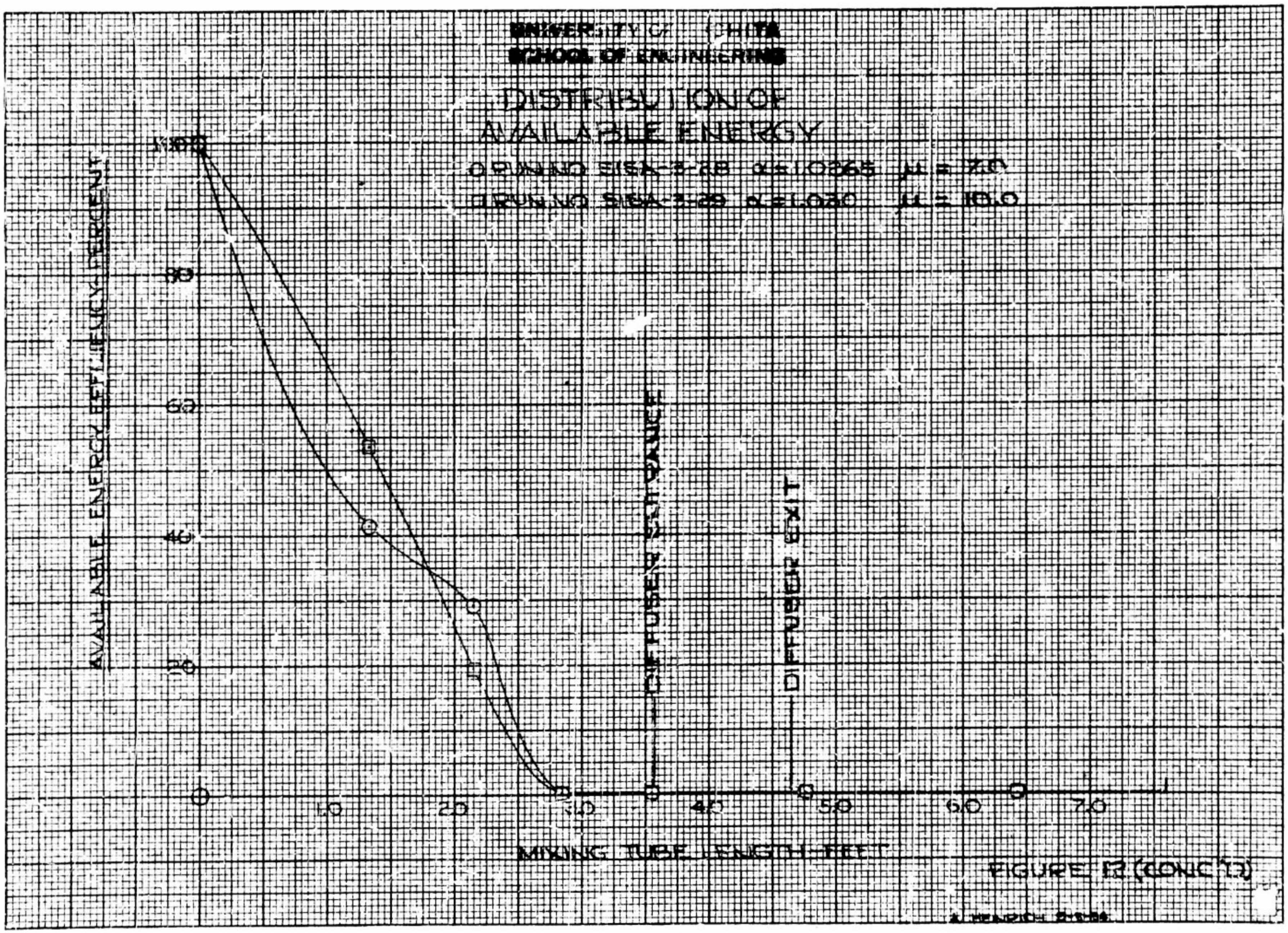

FIGURE 12 (CONC'D)

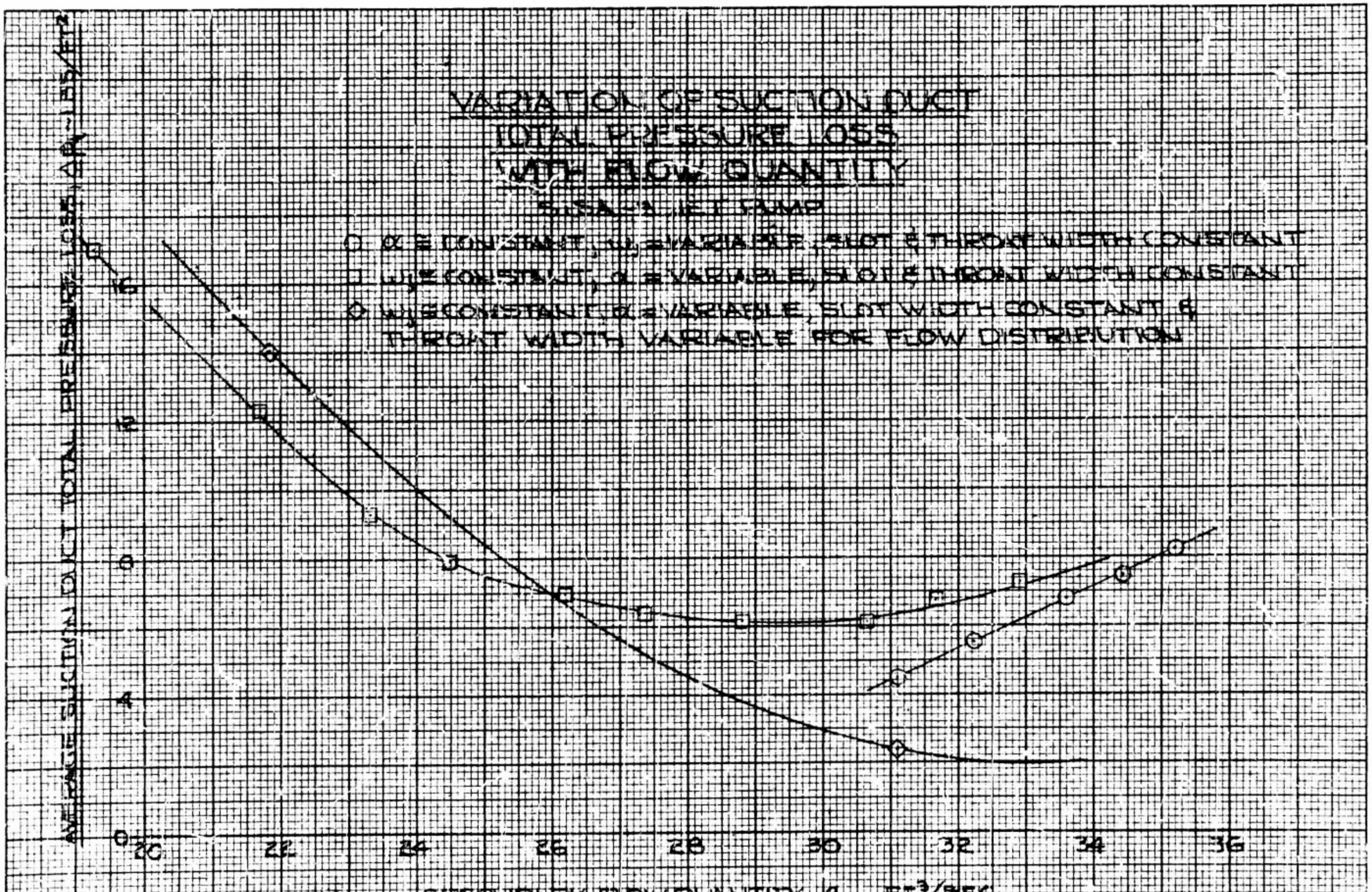
VARIATION OF SUCTION DUCT
TOTAL PRESSURE LOSS
WITH FLOW QUANTITY
○ α = CONSTANT, ω = VARIABLE, SLOT & THROAT WIDTH CONSTANT
□ ω = CONSTANT, α = VARIABLE, SLOT & THROAT WIDTH CONSTANT
◇ ω = CONSTANT, α = VARIABLE, SLOT WIDTH CONSTANT & THROAT WIDTH VARIABLE FOR FLOW DISTRIBUTION
AVERAGE SUCTION DUCT TOTAL PRESSURE LOSS ΔP ~ LBS/FT²
0
4
8
12
16
20
22
24
26
28
30
32
34
36
SECONDARY FLOW QUANTITY, q ~ FT³/SEC

FIGURE 13

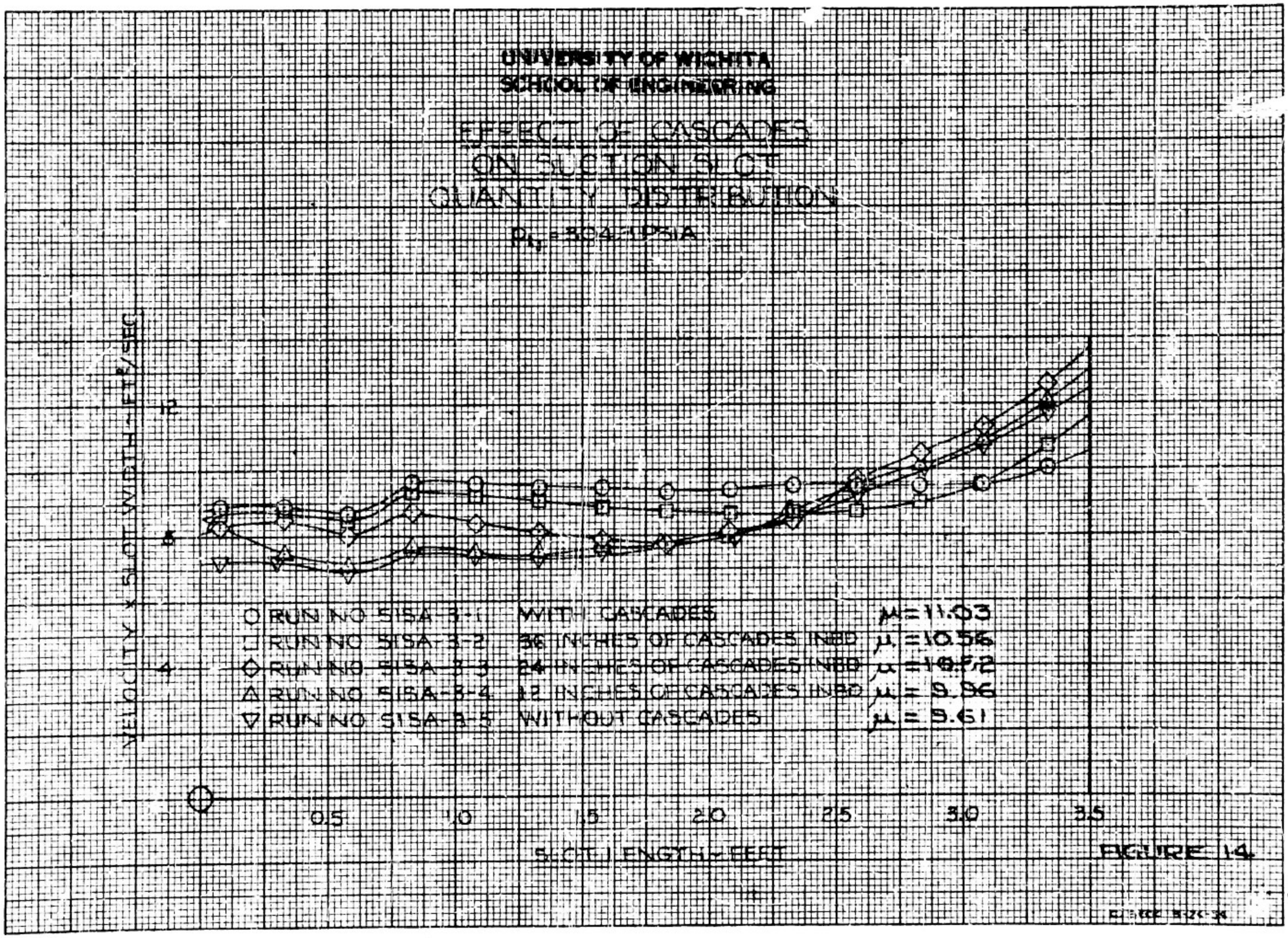
UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING
EFFECT OF CASCADES
ON SUCTION SLOT
QUANTITY DISTRIBUTION
○ RUN NO 51SA-3-1 WITH CASCADES μ = 11.03
□ RUN NO 51SA-3-2 36 INCHES OF CASCADES INBD μ = 10.56
◇ RUN NO 51SA-3-3 24 INCHES OF CASCADES INBD
△ RUN NO 51SA-3-4 12 INCHES OF CASCADES INBD
▽ RUN NO 51SA-3-5 WITHOUT CASCADES μ = 9.61
VELOCITY × SLOT WIDTH ~ FT²/SEC
4
8
12
0.5
1.0
1.5
2.0
2.5
3.0
3.5
SLOT LENGTH ~ FEET

FIGURE 14

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EFFECT OF JET PRESSURE VARIATION
ON SUCTION SLOT QUANTITY DISTRIBUTION

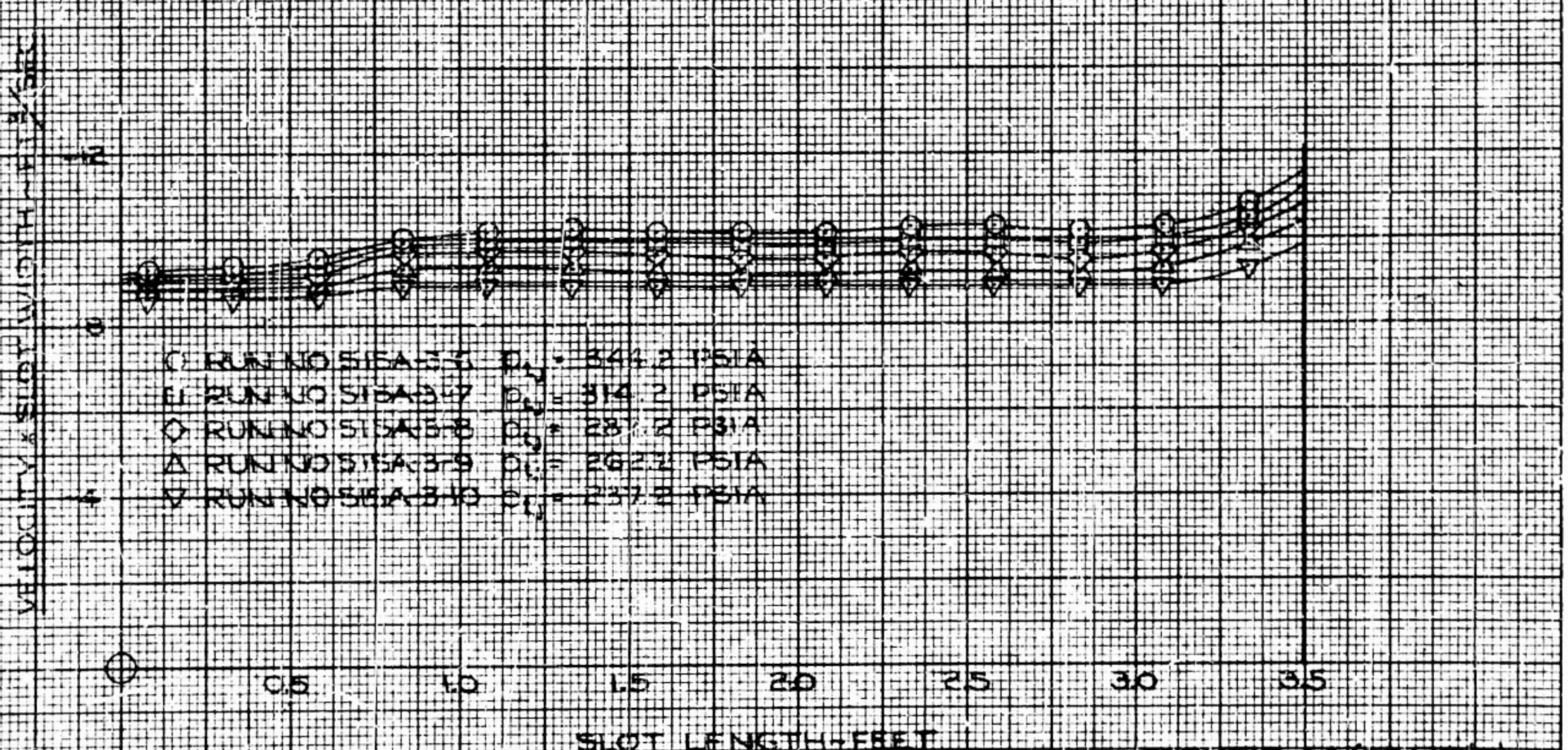


FIGURE 14 (CONT'D)

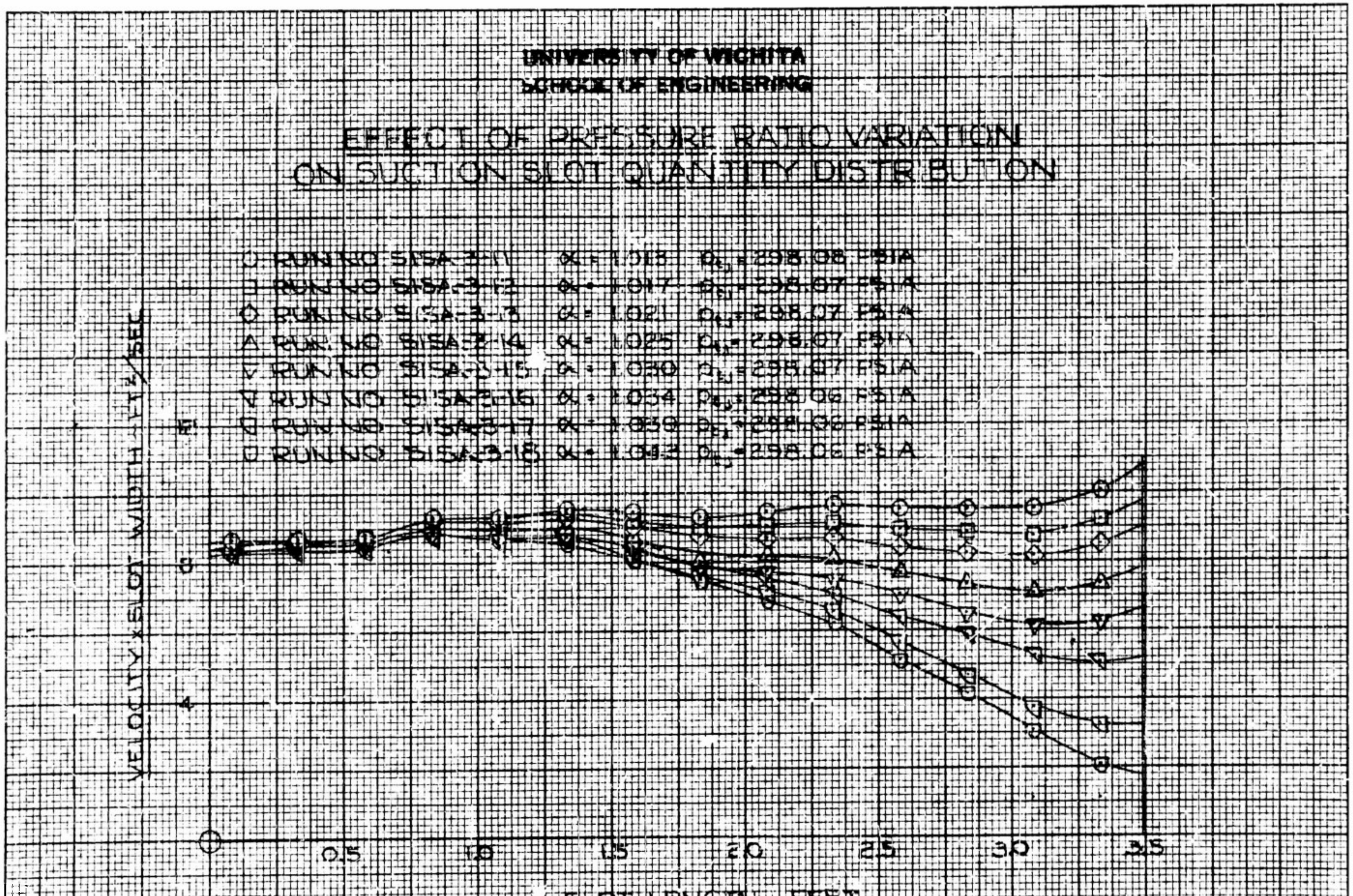


FIGURE 14(CONT'D)

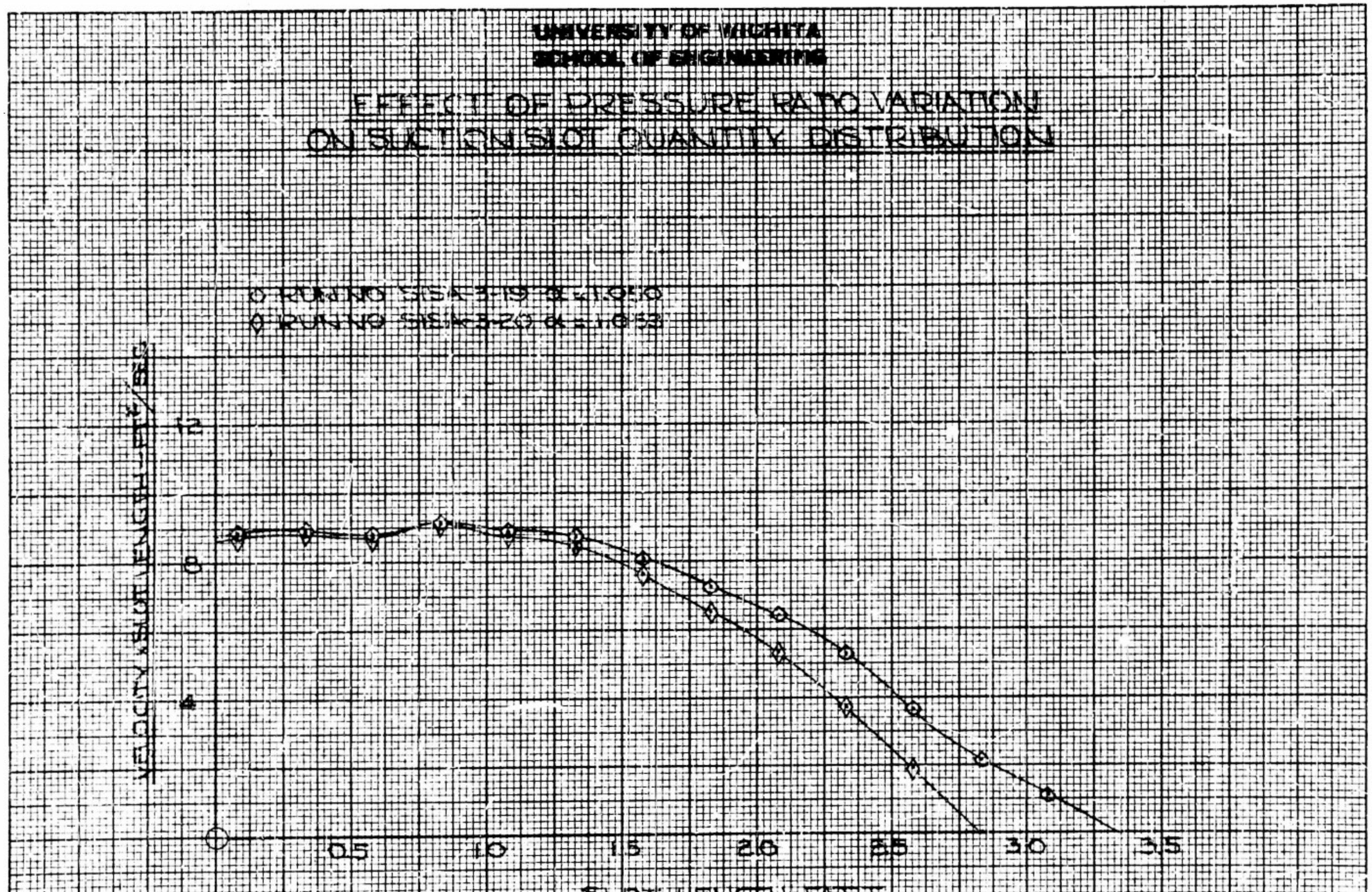


FIGURE 14 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

EFFECT OF PRESSURE RATIO VARIATION
ON SUCTION SLOT QUANTITY DISTRIBUTION

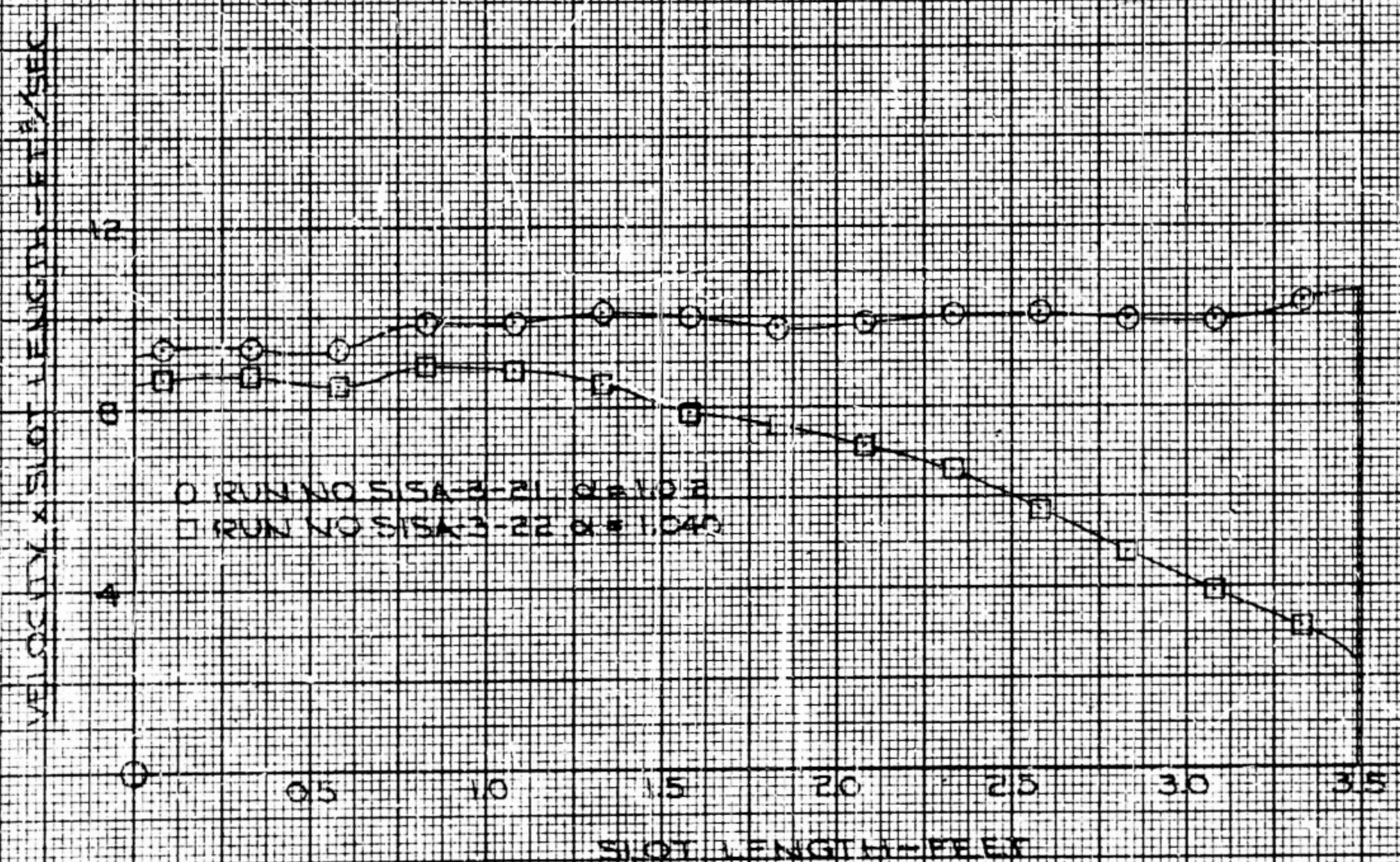


FIGURE 14 (CONT'D)

A. HEINRICH 4-8-54

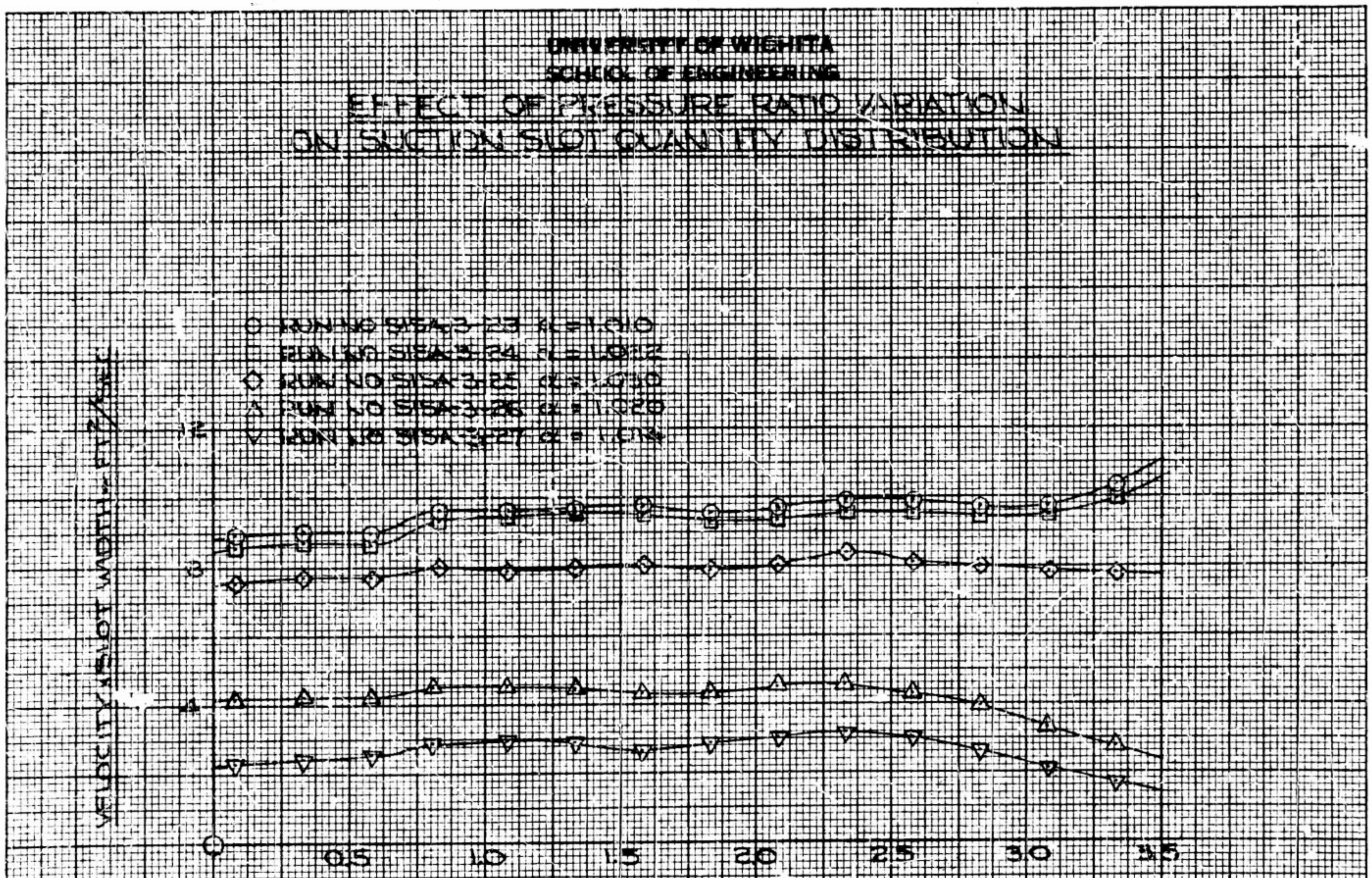


FIGURE 14 (CONT'D)

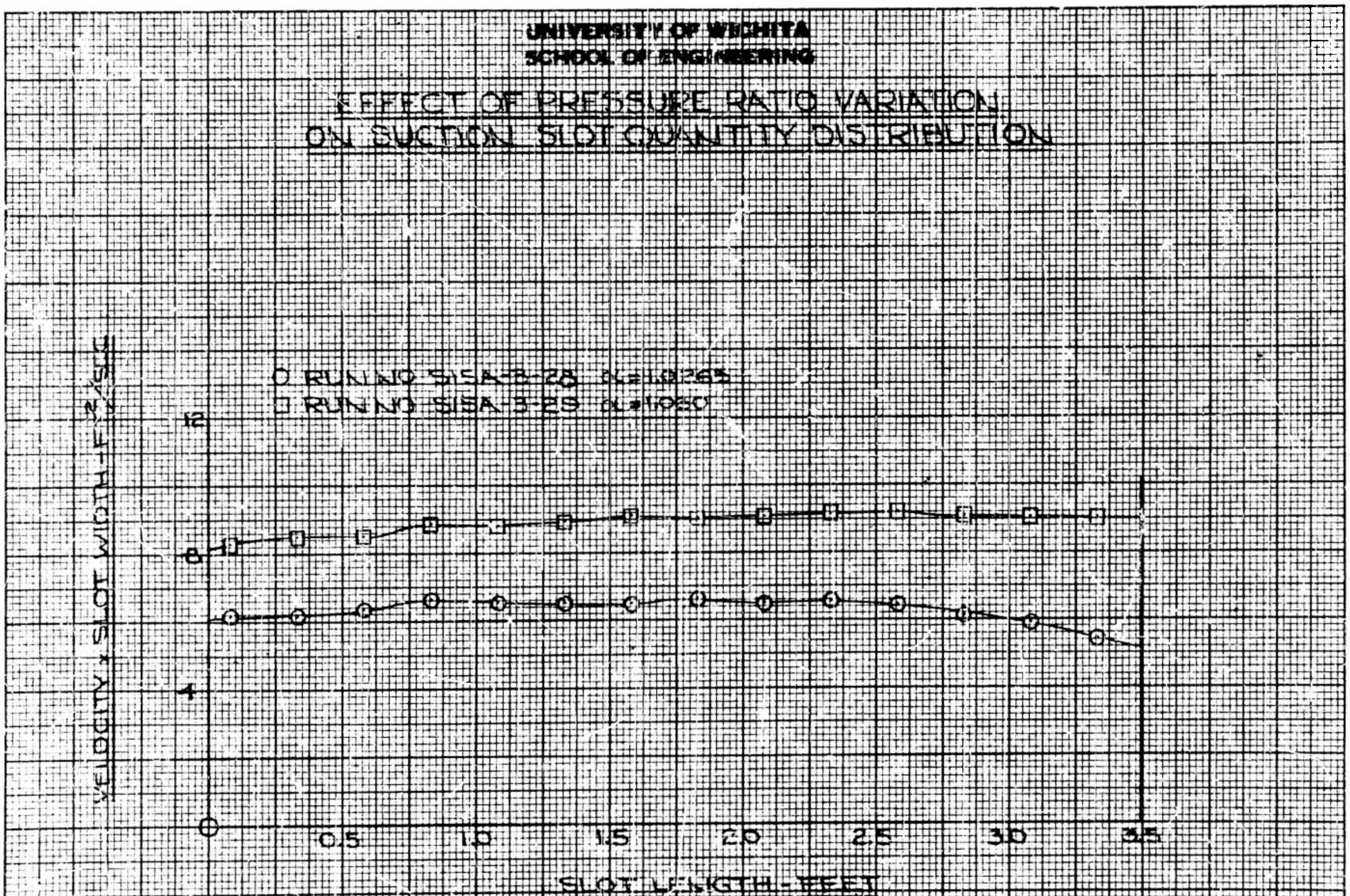


FIGURE 14 (CONC'D)

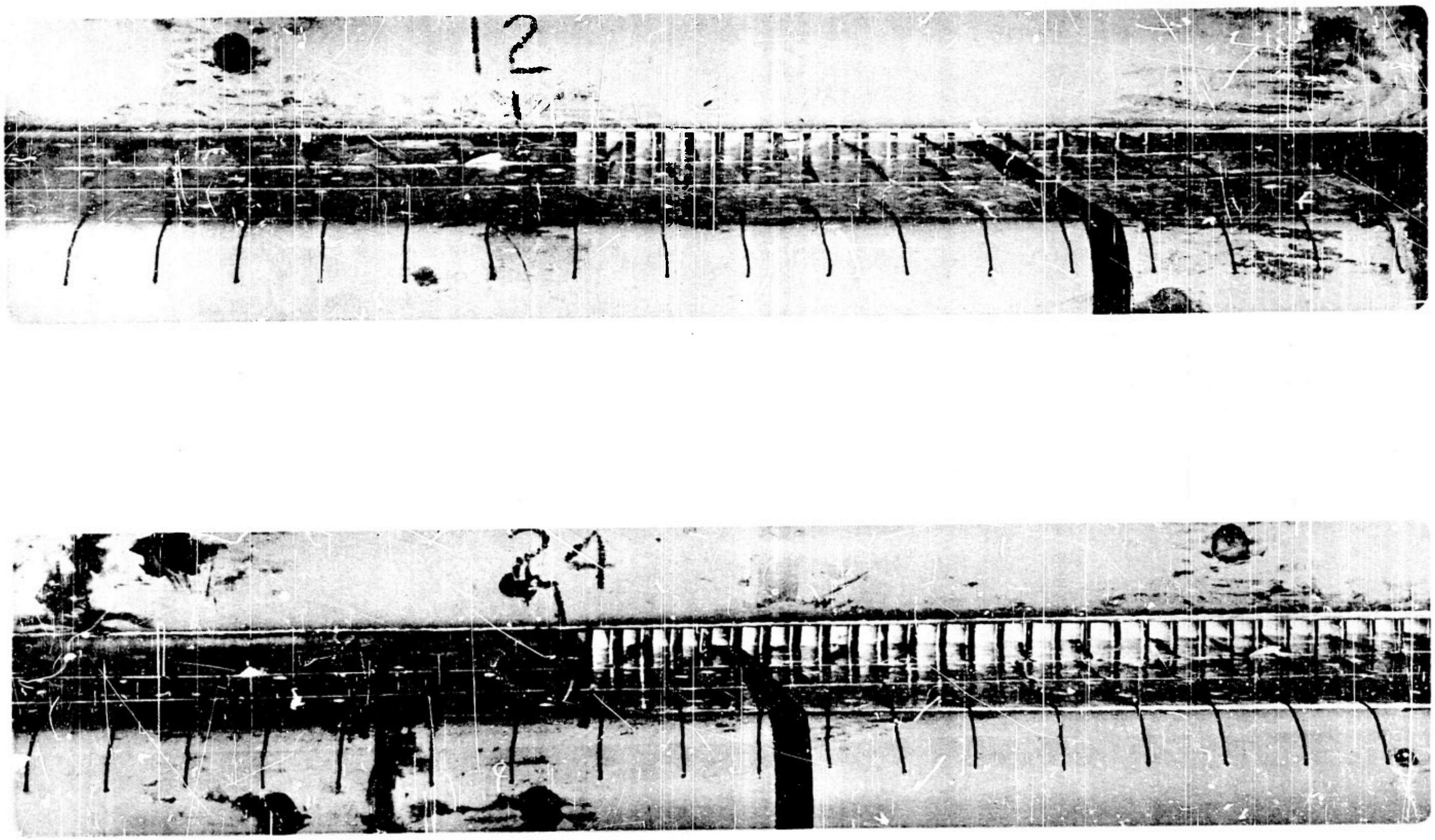


Figure 15.- Suction duct flow pattern.

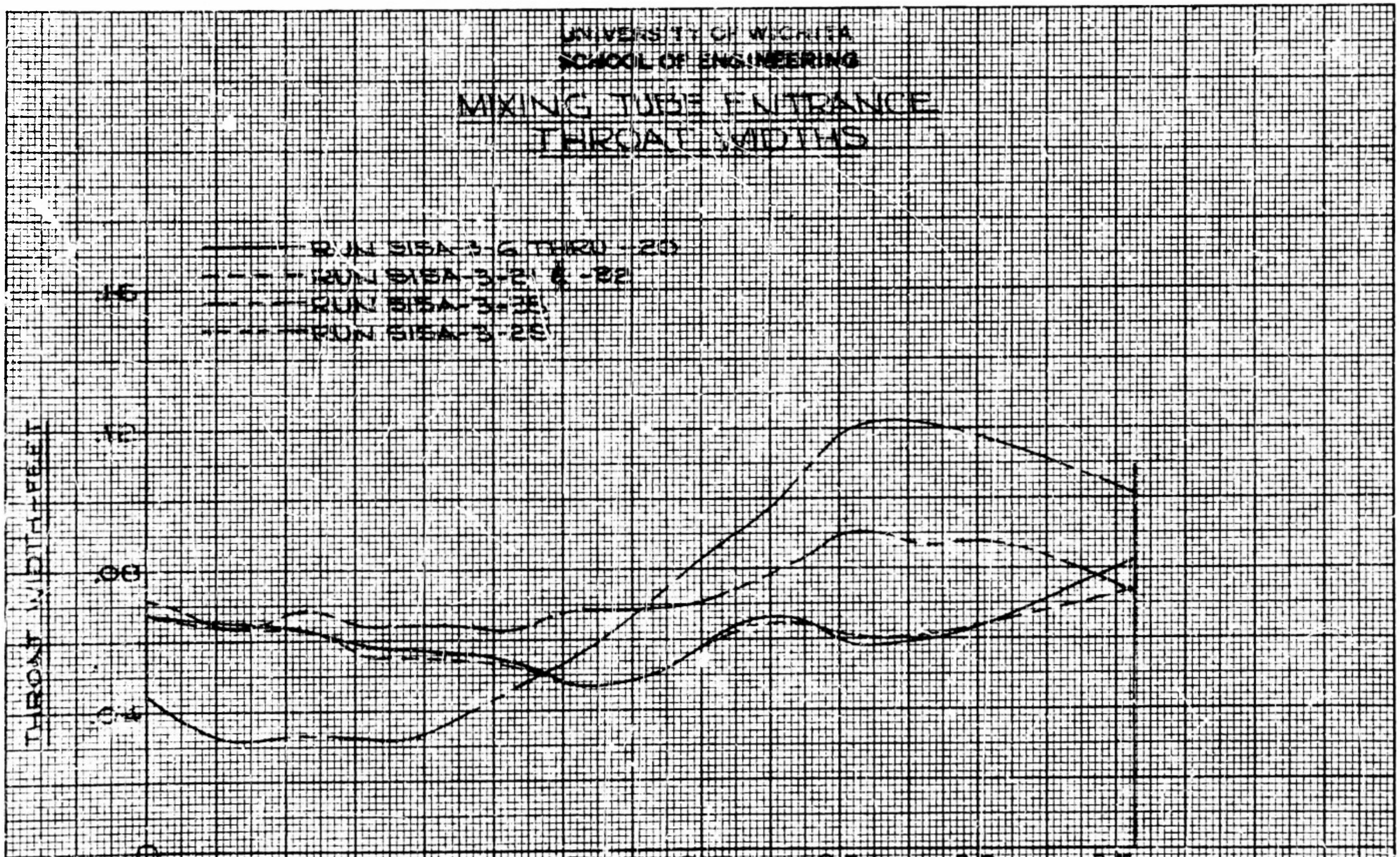
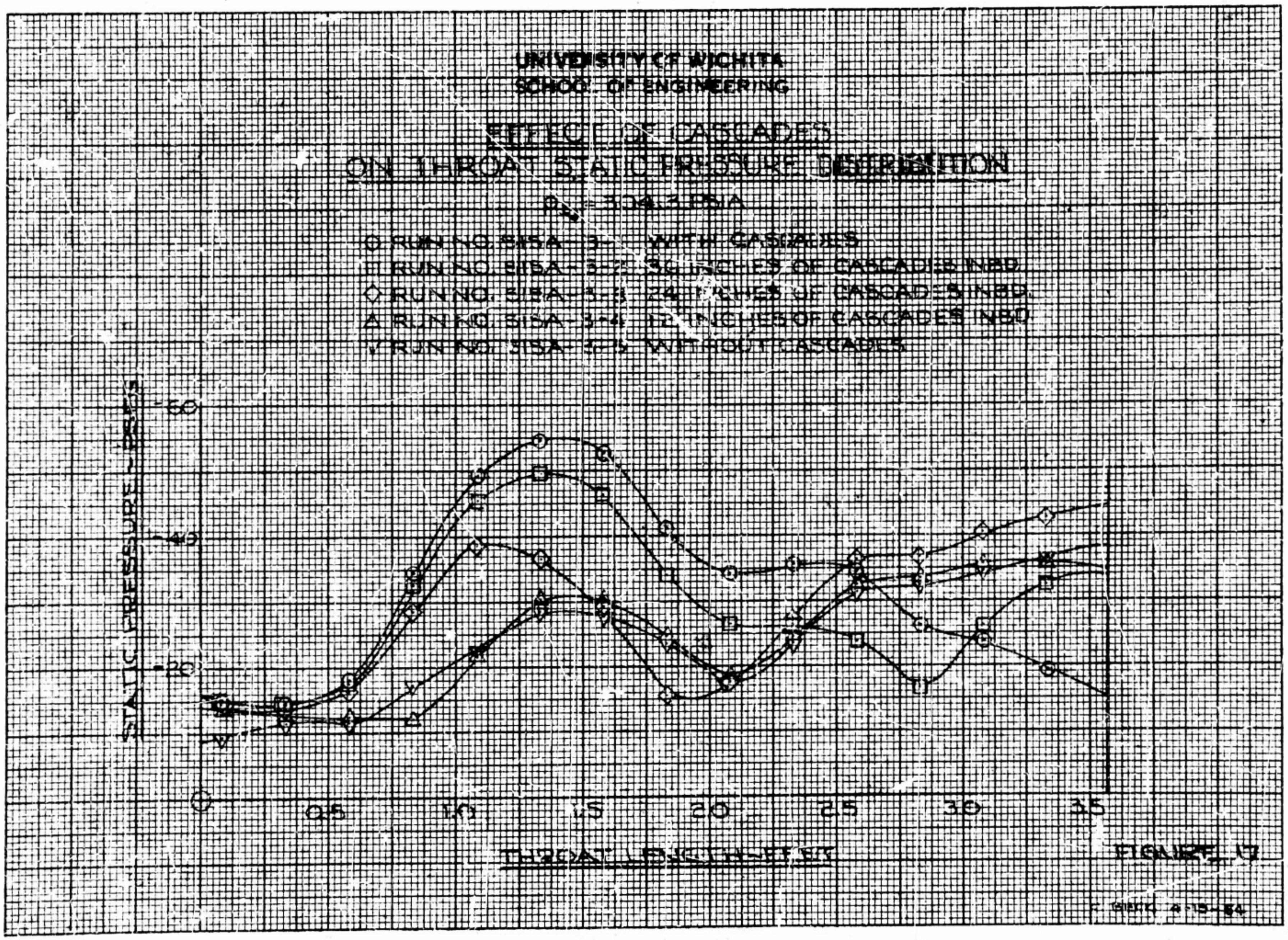

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING
MIXING TUBE ENTRANCE
THROAT WIDTHS
RUN SISA-3-6 THRU -20
RUN SISA-3-21 & -22
RUN SISA-3-23
RUN SISA-3-25
.16
.12
.08
.04
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
THROAT WIDTH—FEET
THROAT LENGTH—FEET

FIGURE 16


UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING
EFFECT OF CASCADES
ON THROAT STATIC PRESSURE DISTRIBUTION
○ RUN NO. 515A-3-1 WITH CASCADES
□ RUN NO. 515A-3-2 36 INCHES OF CASCADES INBD
◇ RUN NO. 515A-3-3 24 INCHES OF CASCADES INBD
△ RUN NO. 515A-3-4 12 INCHES OF CASCADES INBD
▽ RUN NO. 515A-3-5 WITHOUT CASCADES
STATIC PRESSURE
60
40
20
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
THROAT LENGTH - FEET
FIGURE 17
4-15-54

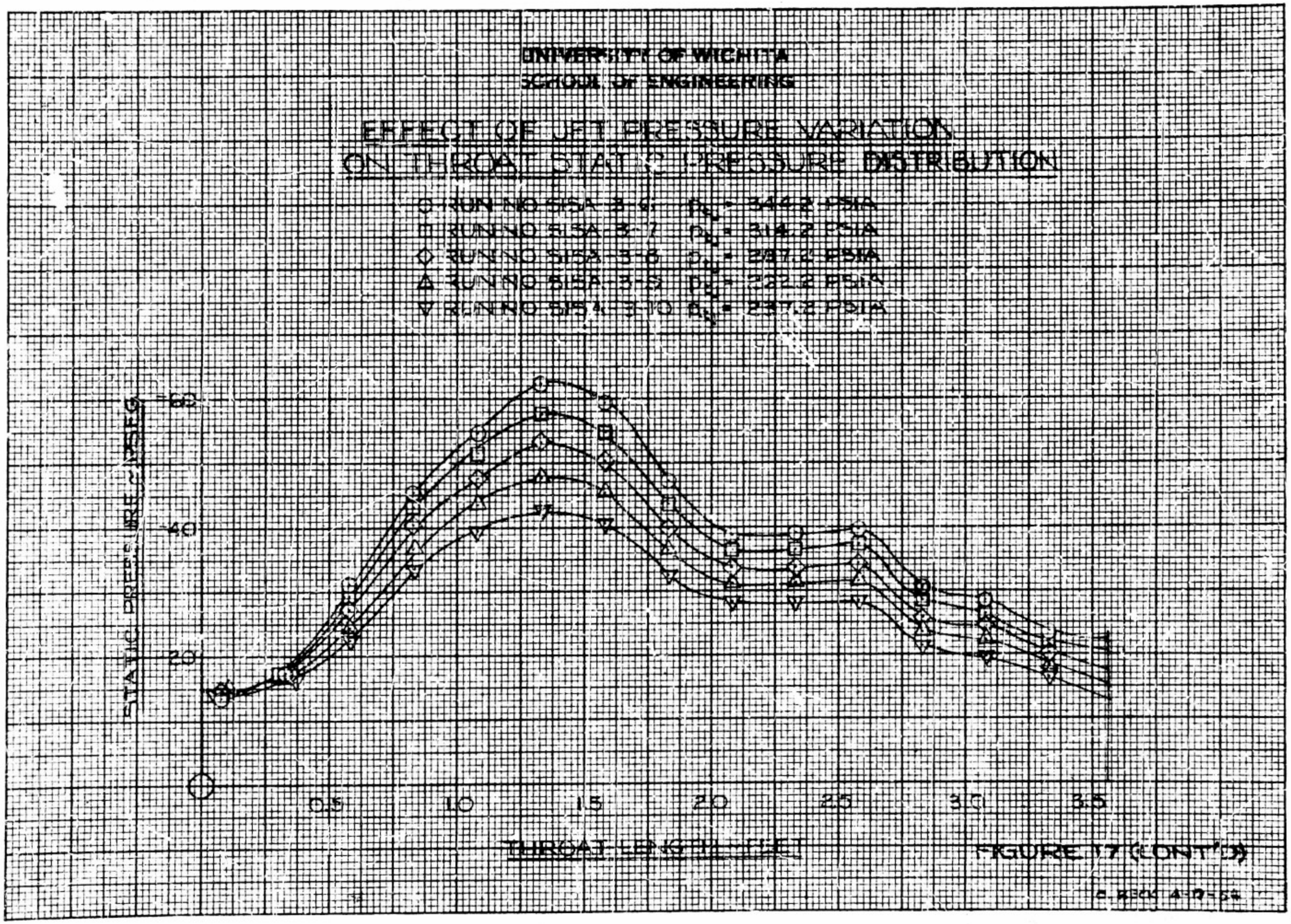


FIGURE 17 (CONT'D)

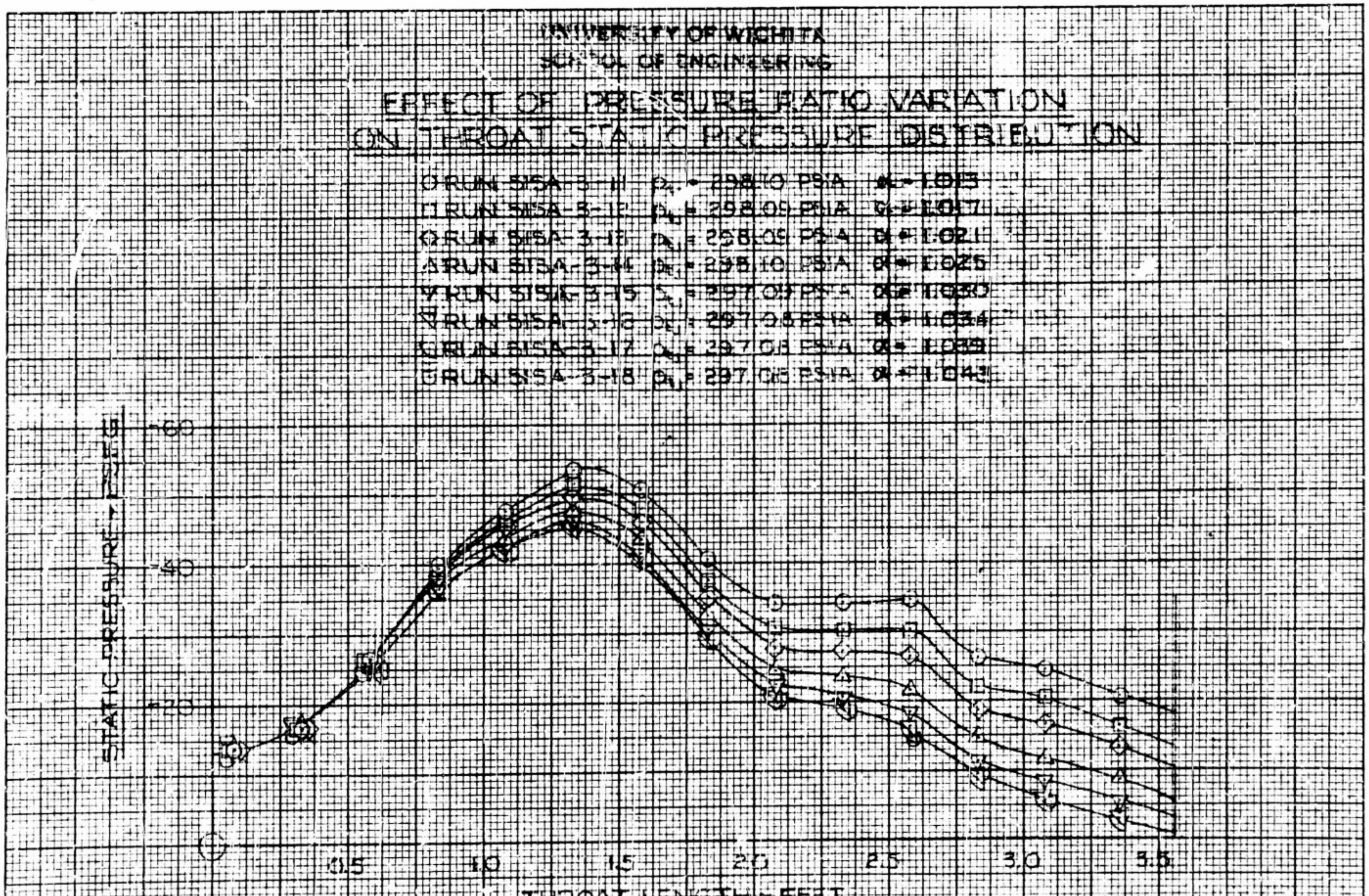


FIGURE 17 (CONT'D)

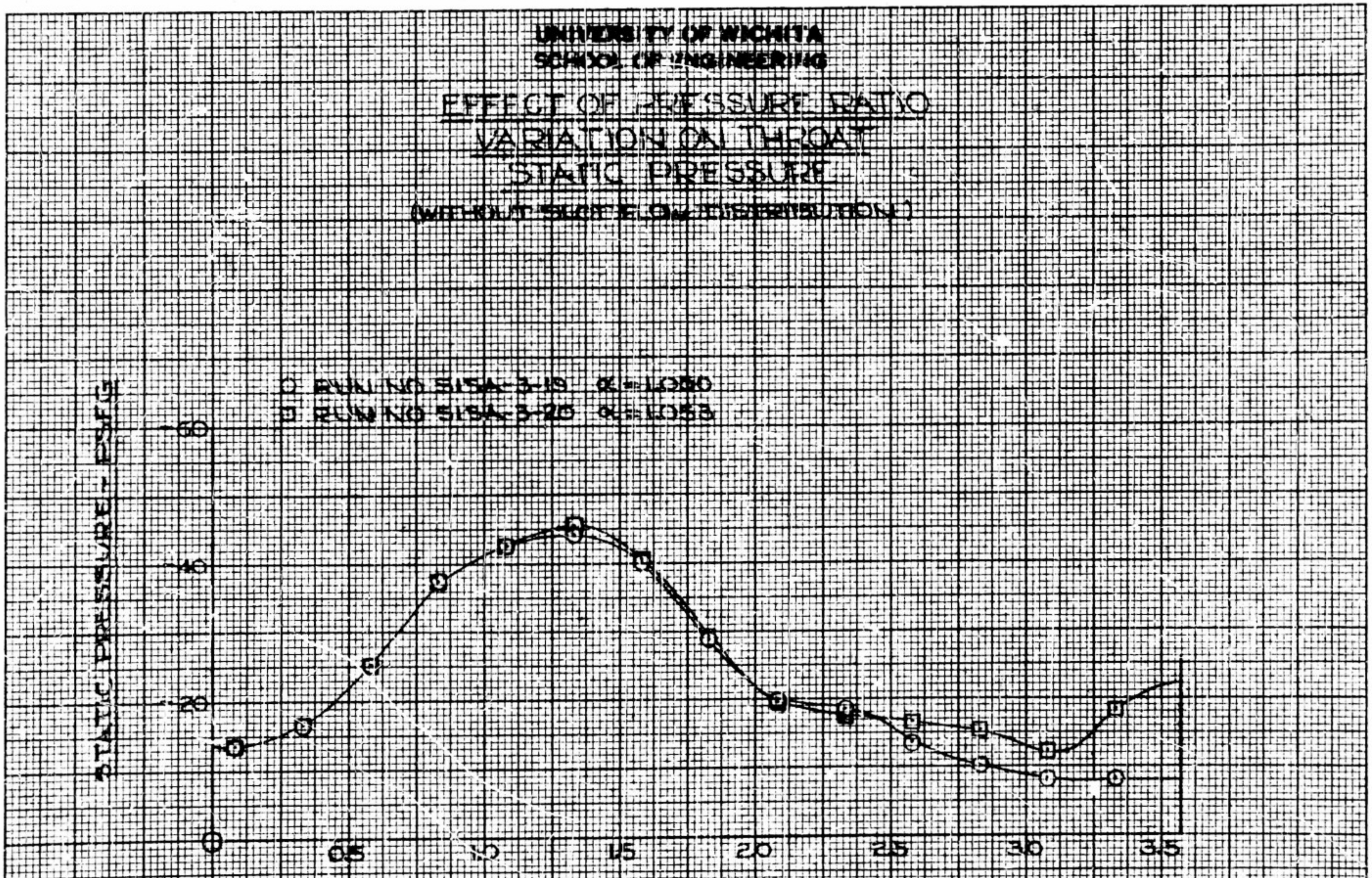


FIGURE 17 (CONT'D)

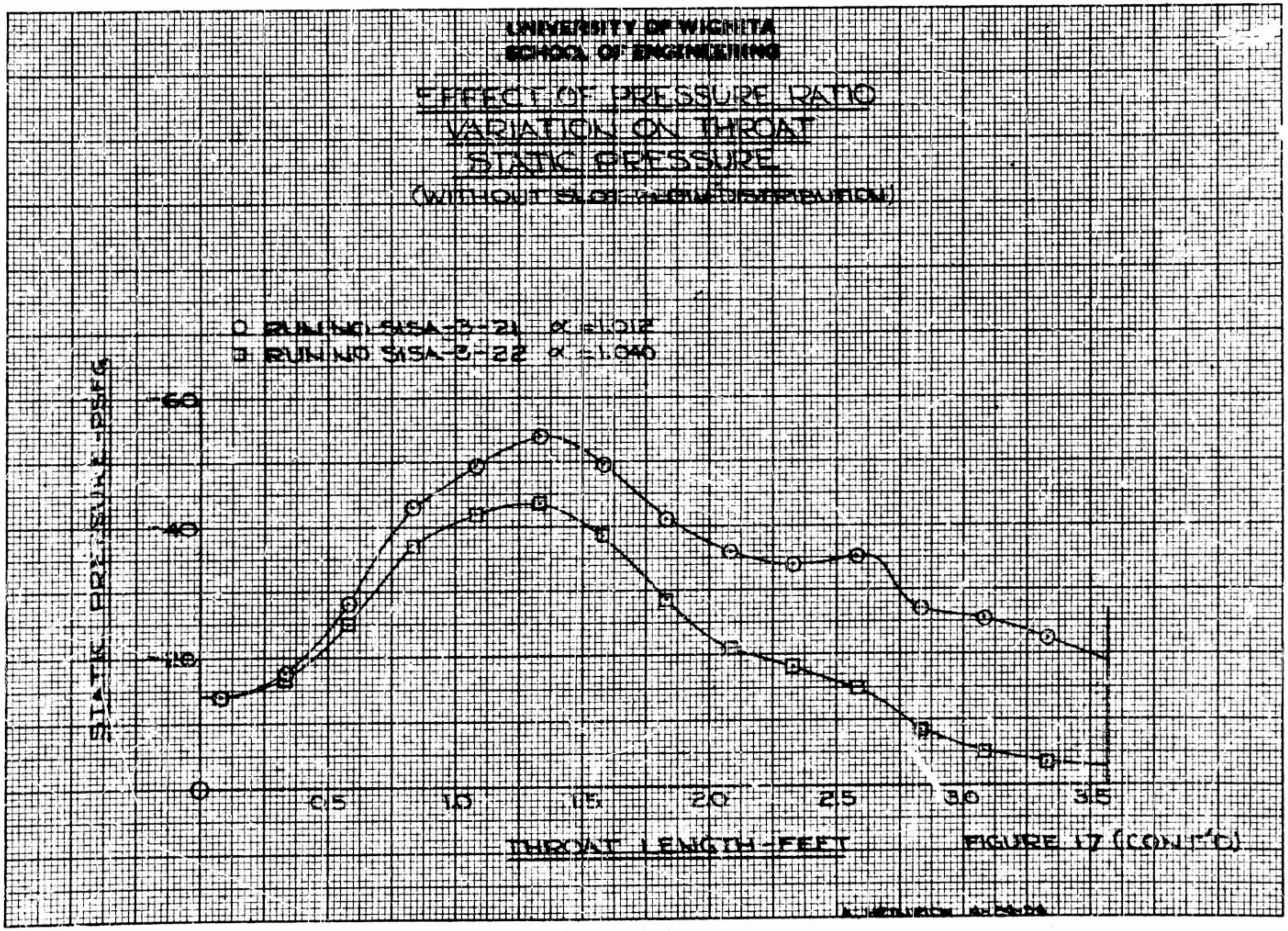


FIGURE 17 (CONT'D)

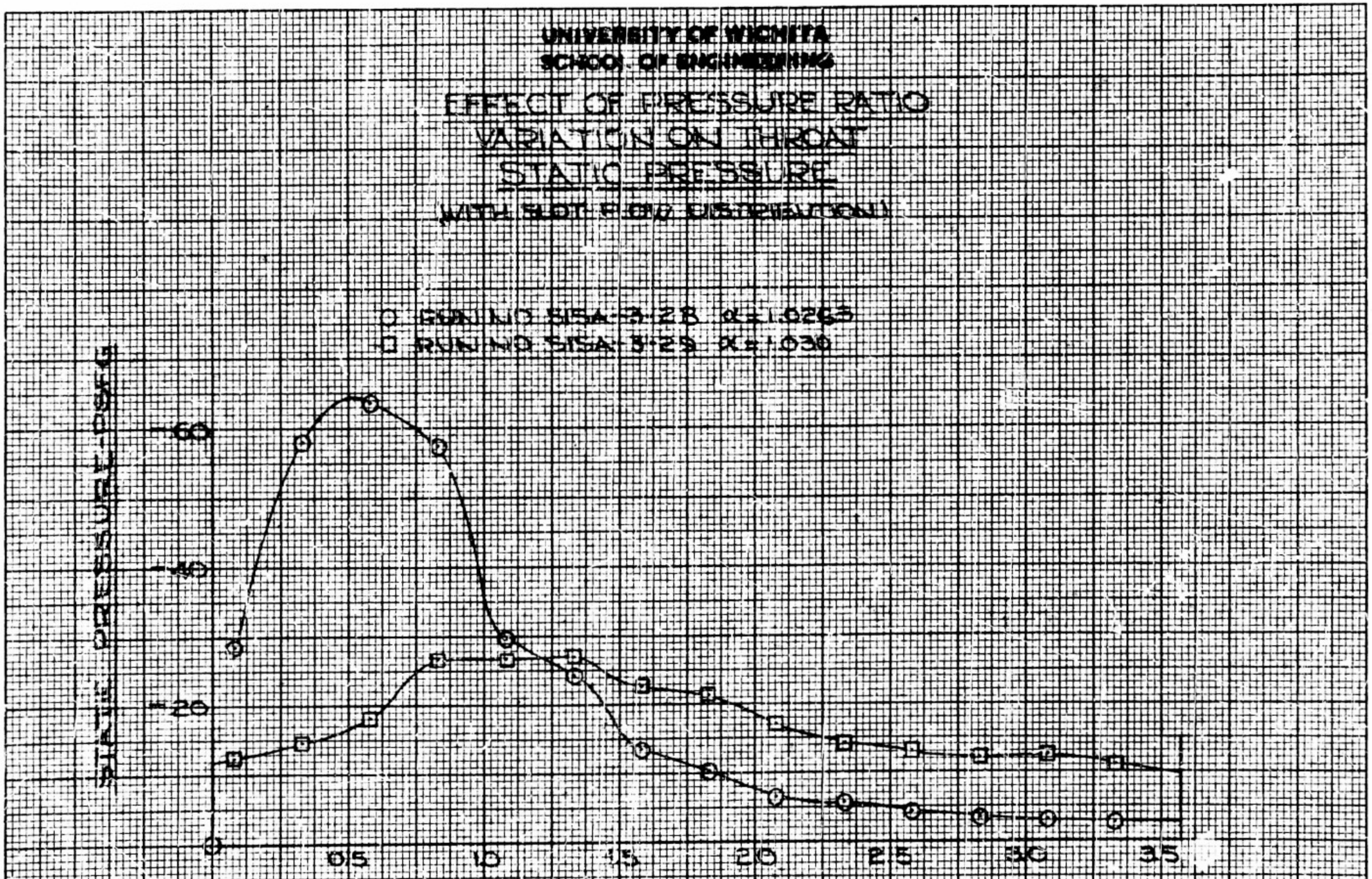


FIGURE 17 (CONC'D)

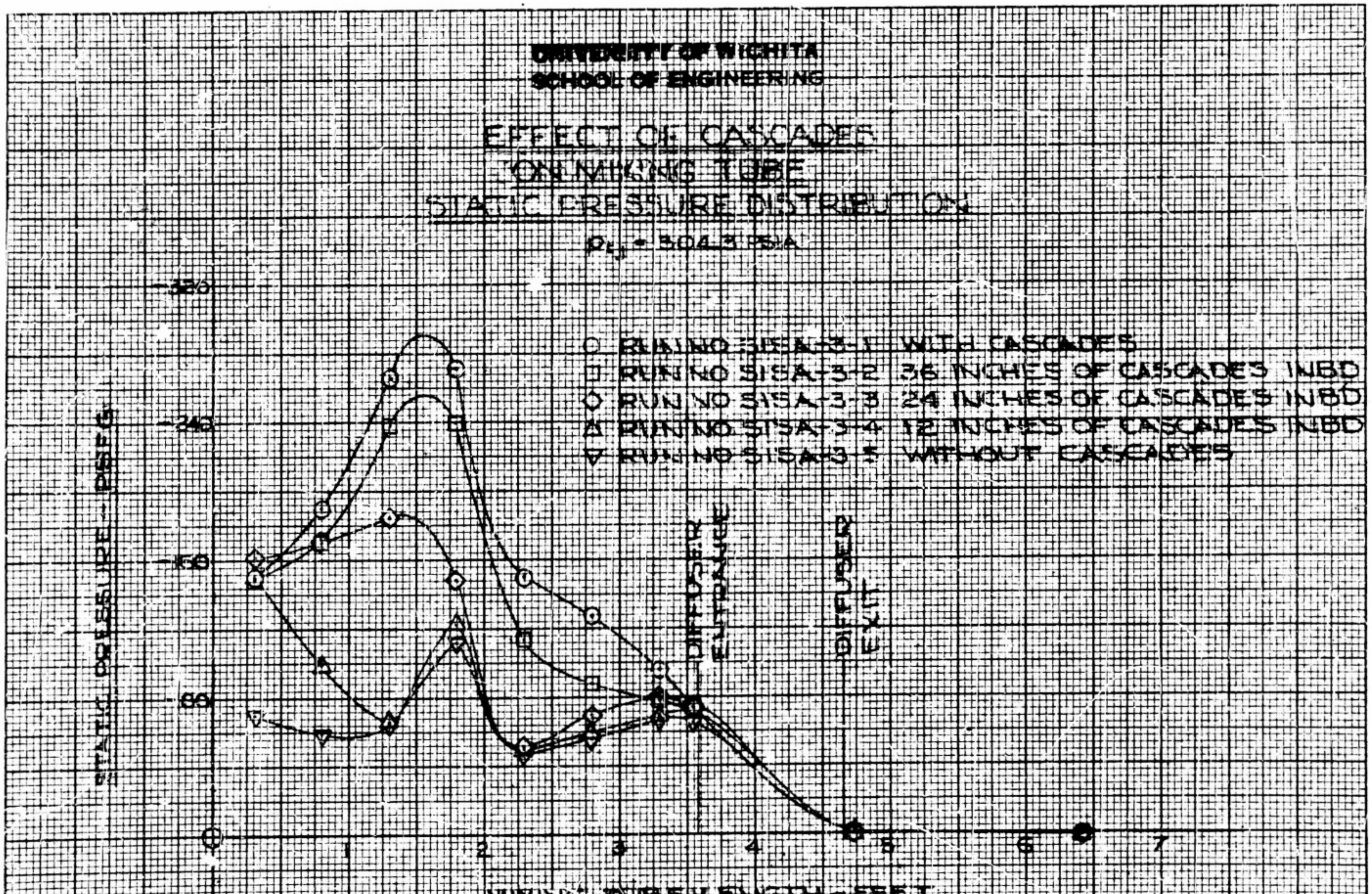

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING
EFFECT OF CASCADES
ON MIXING TUBE
STATIC PRESSURE DISTRIBUTION
P_{t_j} = 304.3 PSIA
○ RUN NO 515A-3-1 WITH CASCADES
□ RUN NO 515A-3-2 36 INCHES OF CASCADES INBD
◇ RUN NO 515A-3-3 24 INCHES OF CASCADES INBD
△ RUN NO 515A-3-4 12 INCHES OF CASCADES INBD
▽ RUN NO 515A-3-5 WITHOUT CASCADES
STATIC PRESSURE - PSFG
-320
-240
-160
-80
0
1
2
3
4
5
6
7
DIFFUSER ENTRANCE
DIFFUSER EXIT
MIXING TUBE LENGTH - FEET

FIGURE 18

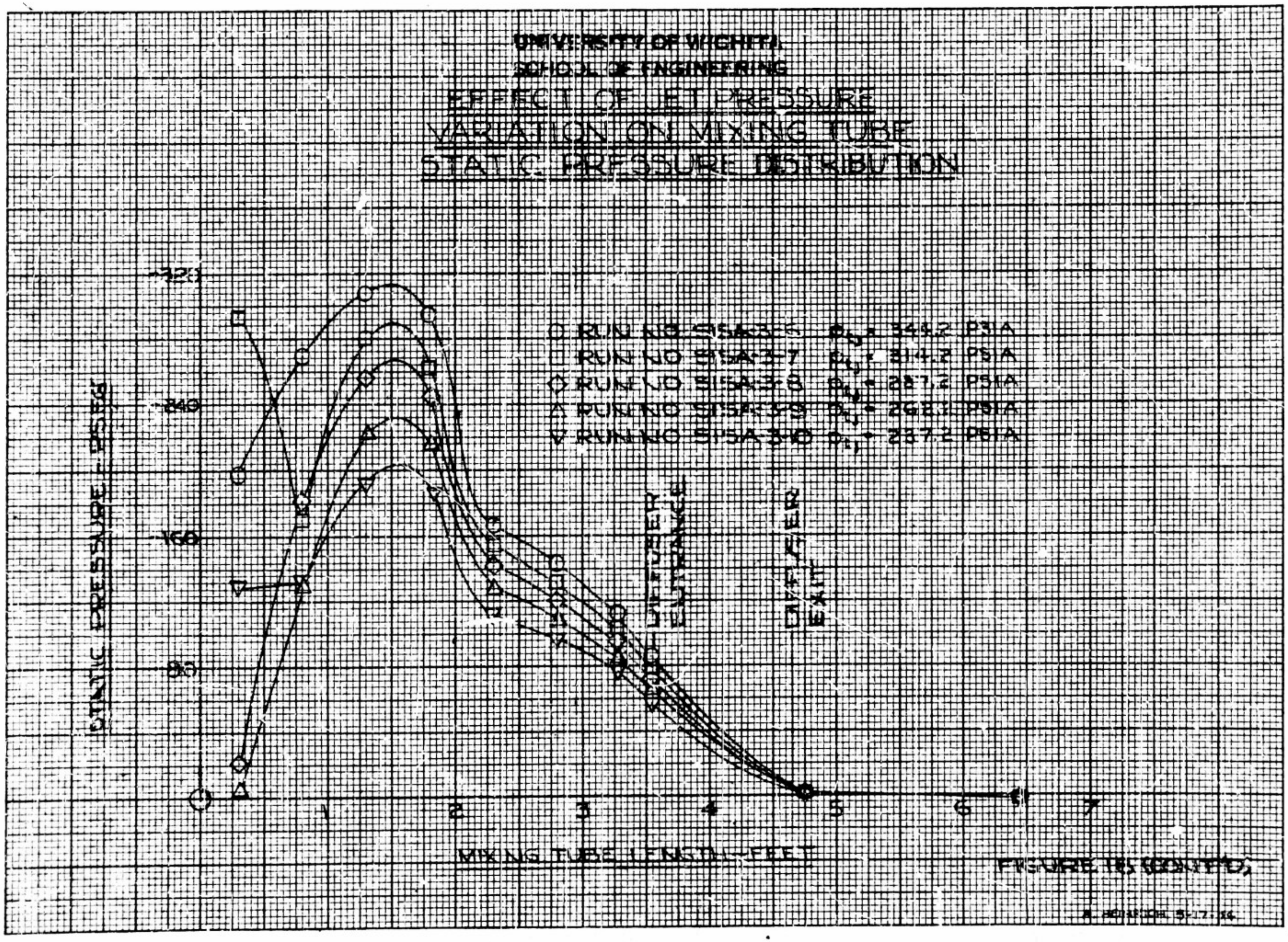


FIGURE 15 (CONT'D)

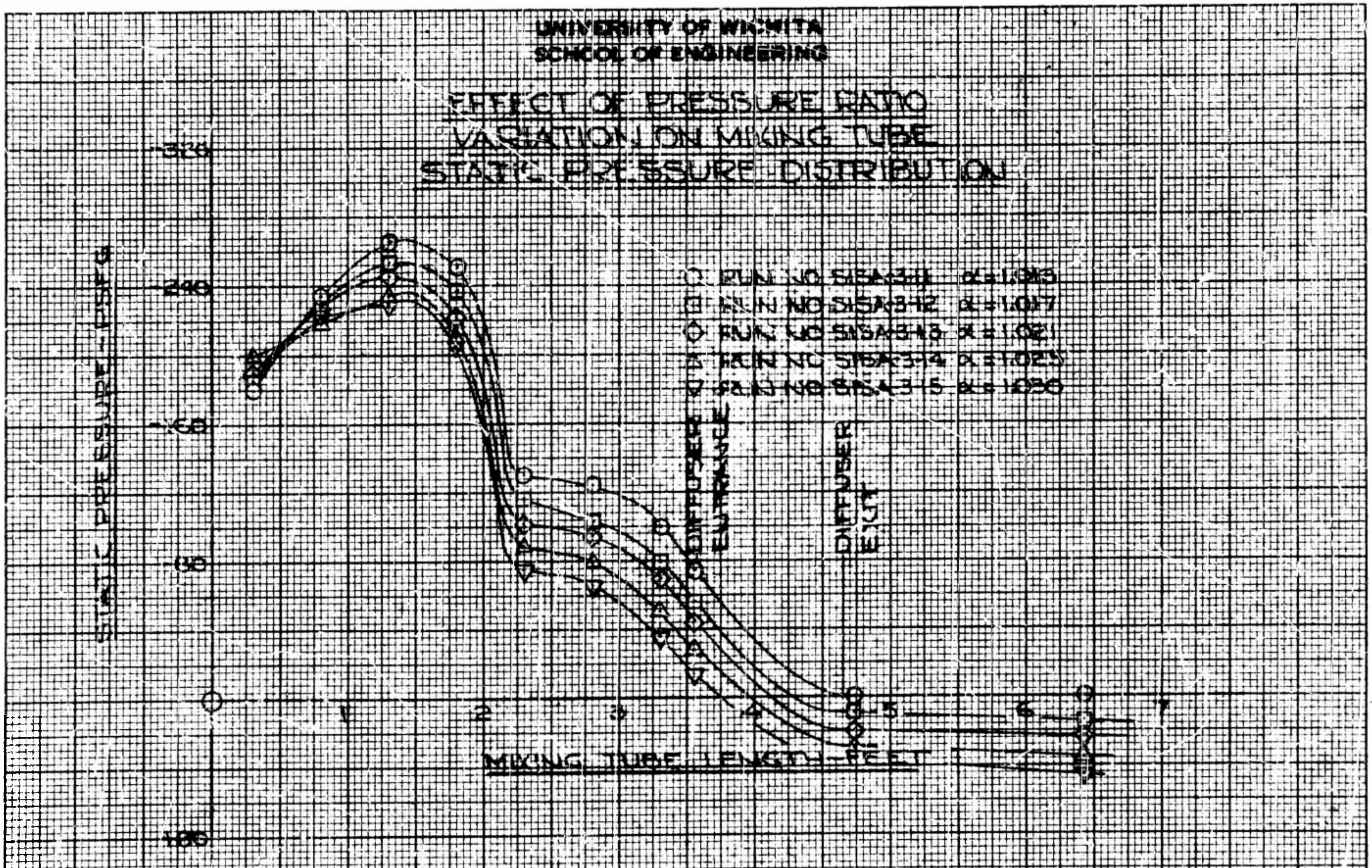


FIGURE 13 (CONT'D)

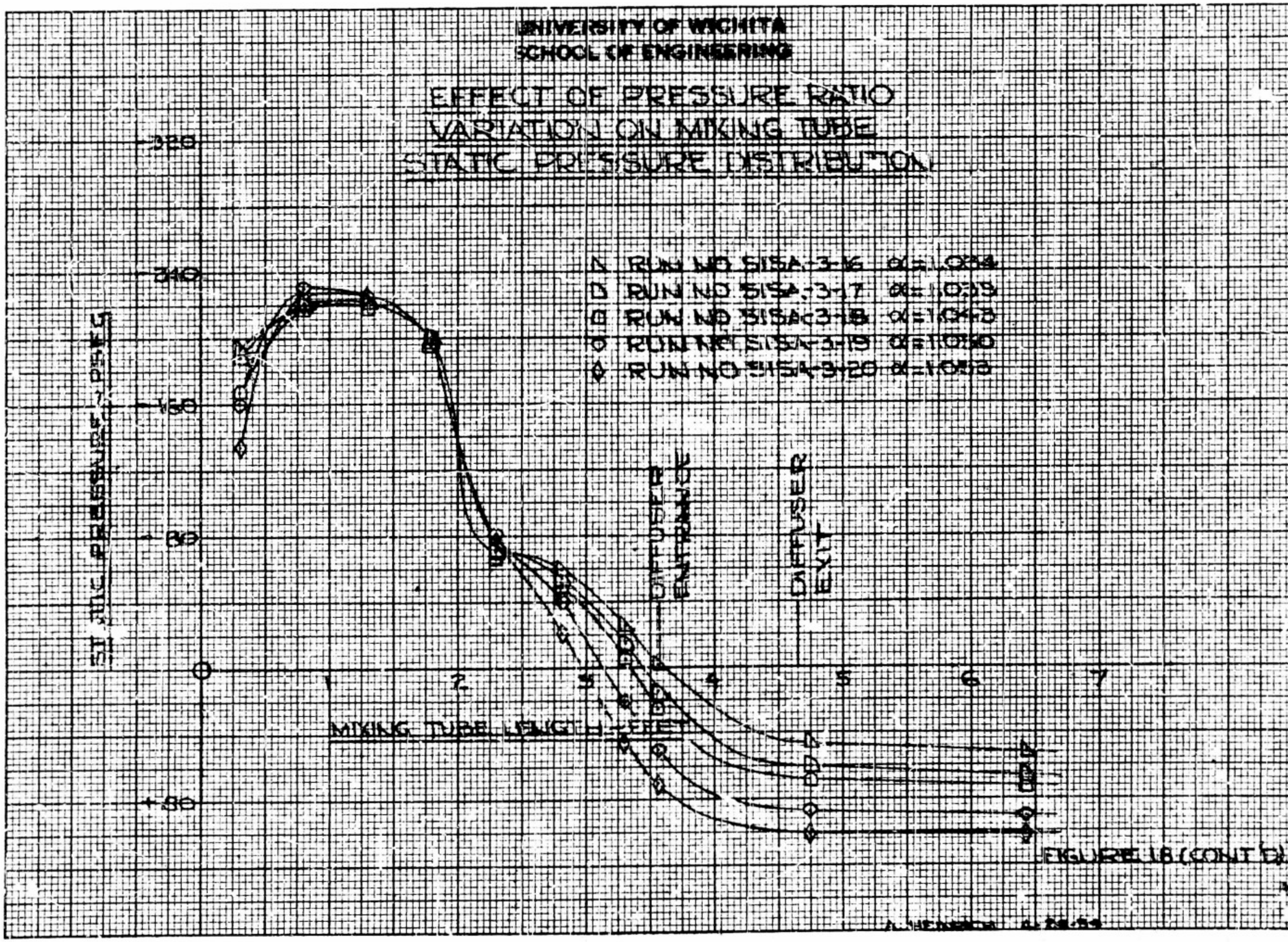


FIGURE 18 (CONT'D)

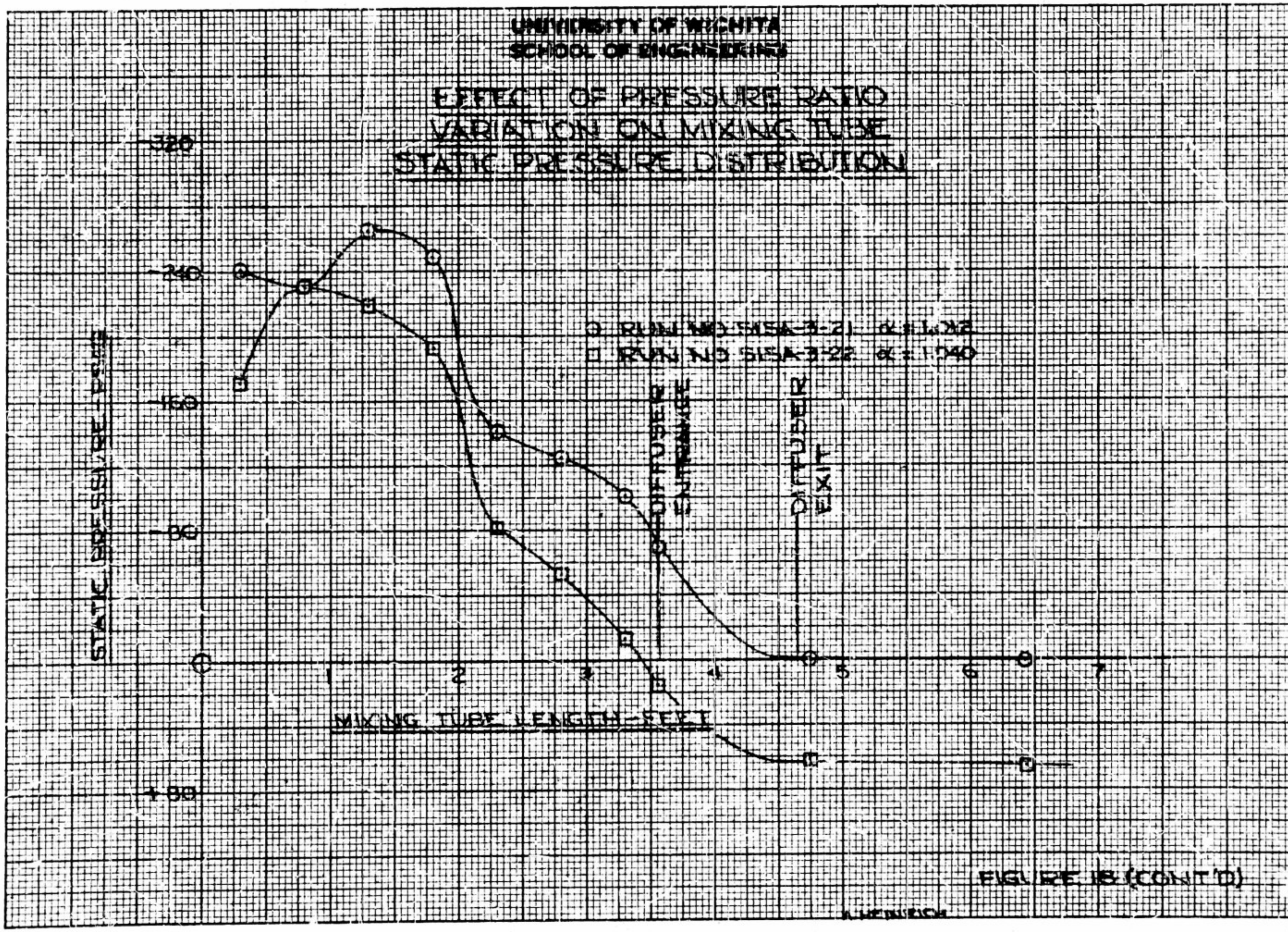


FIGURE 18 (CONT'D)

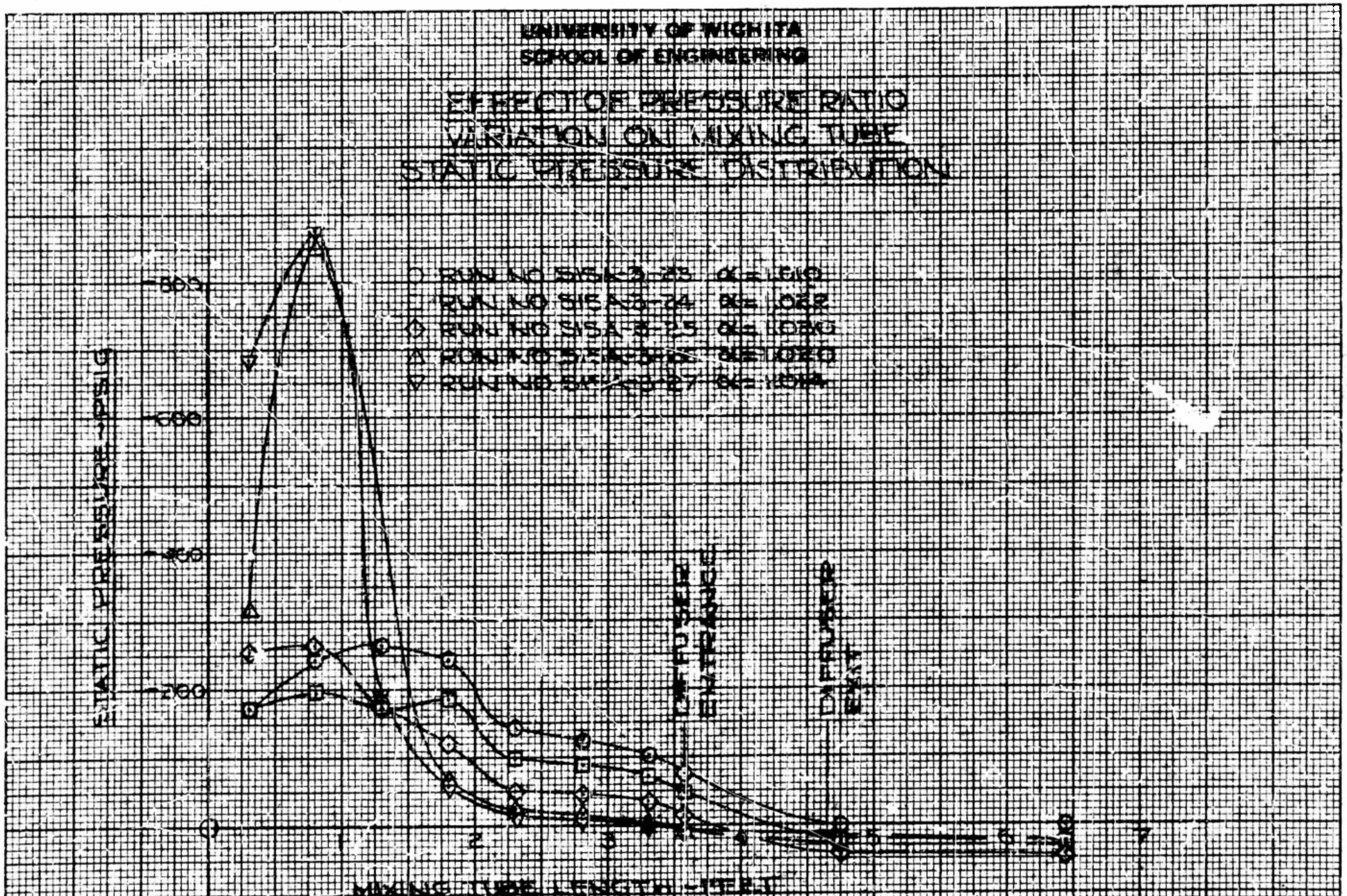


FIGURE 15 (CONT'D)

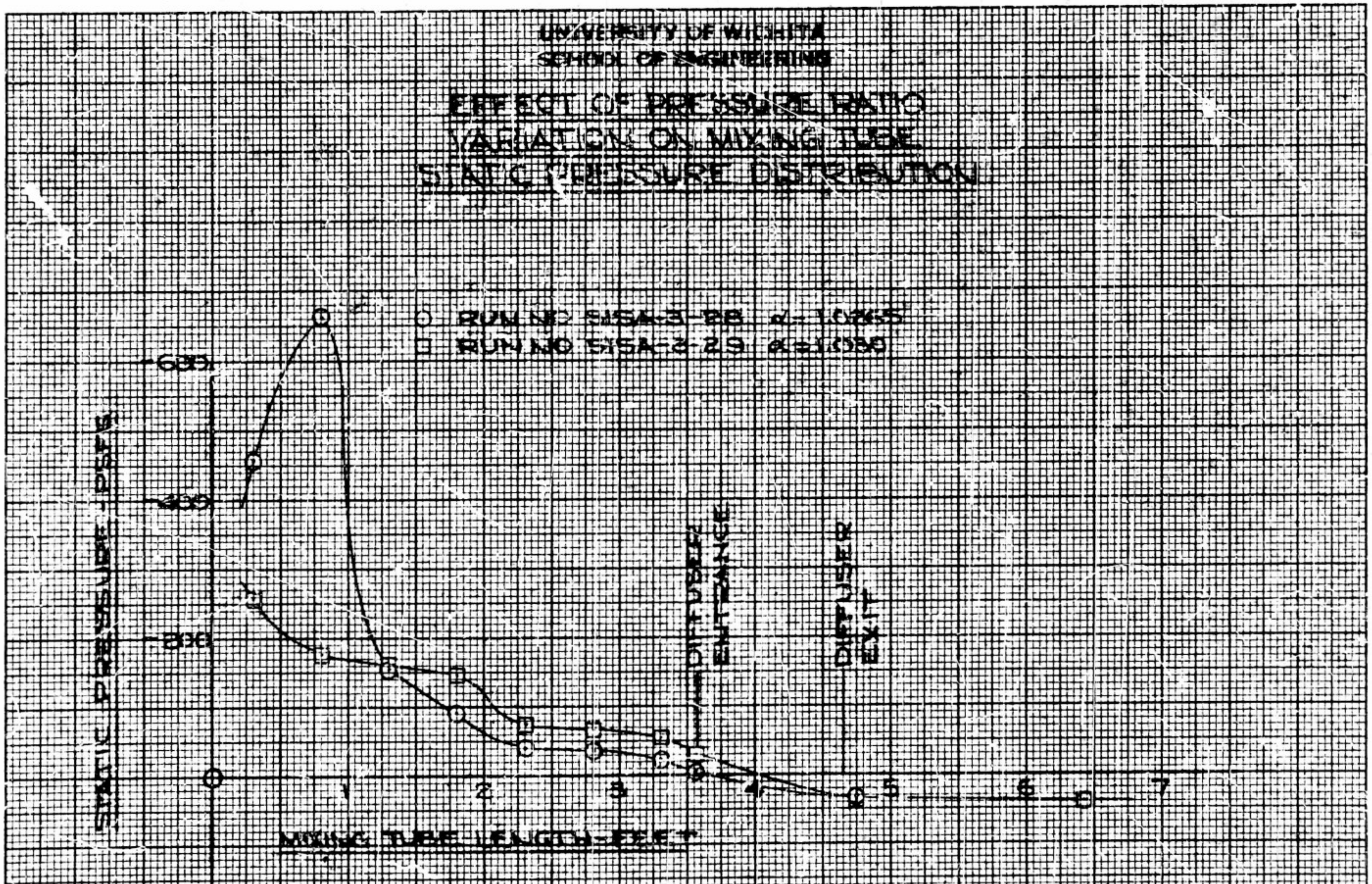


FIGURE 18 (CONC'D)

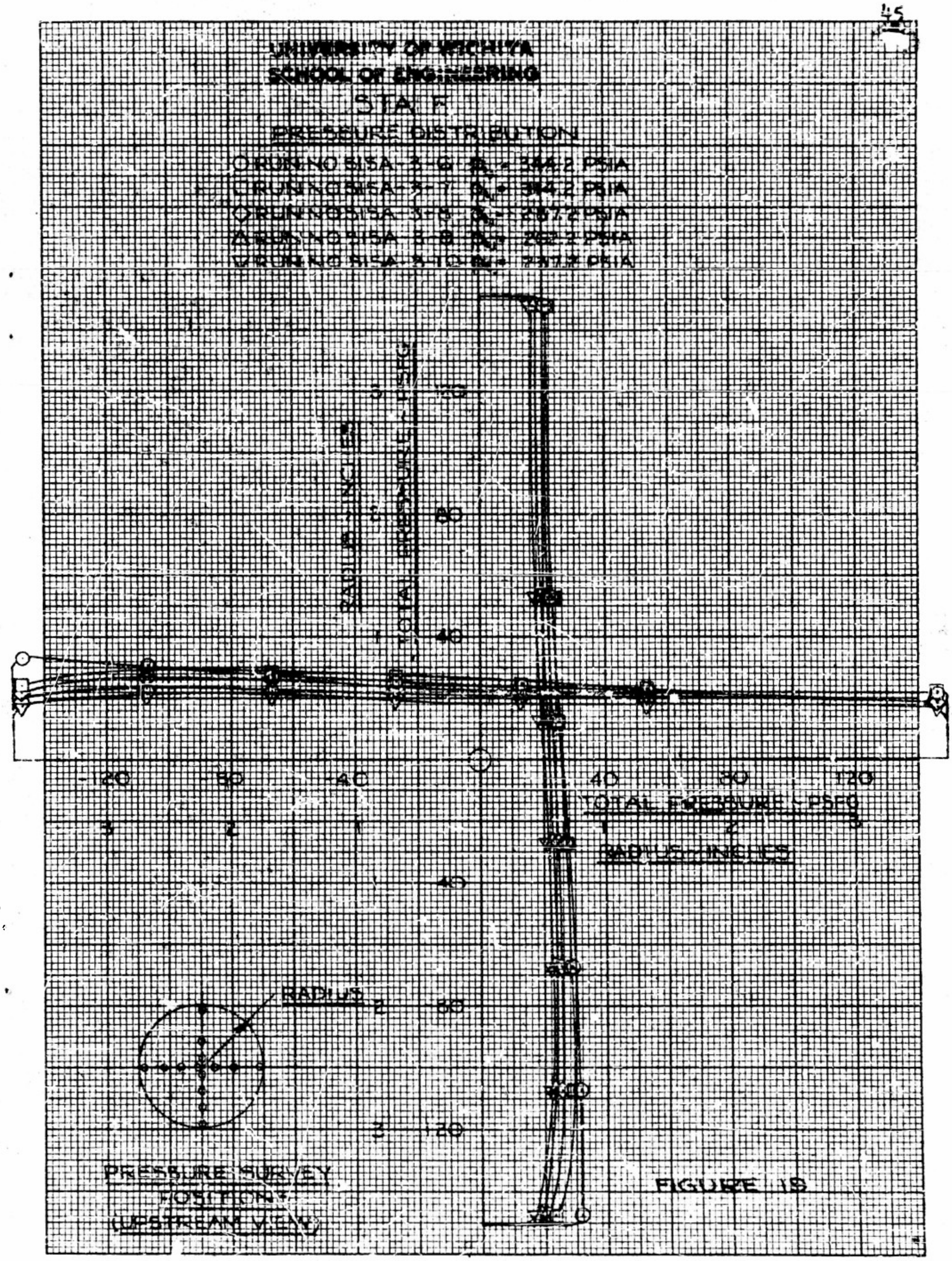

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING
STA F
PRESSURE DISTRIBUTION
TOTAL PRESSURE - PSFG
RADIUS - INCHES
RADIUS
PRESSURE SURVEY
POSITION
(UPSTREAM VIEW)

FIGURE 19

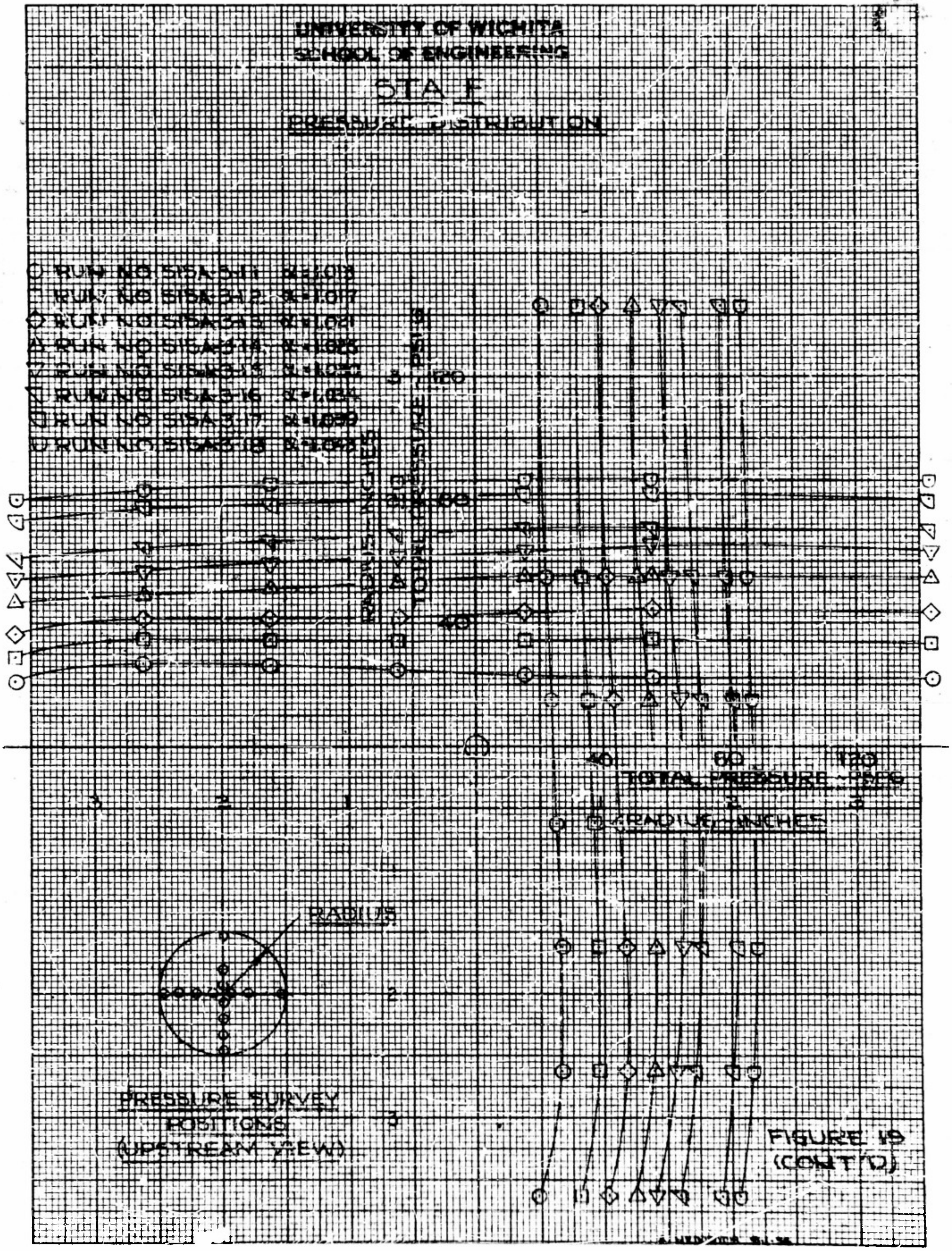


FIGURE 19
(CONT'D)

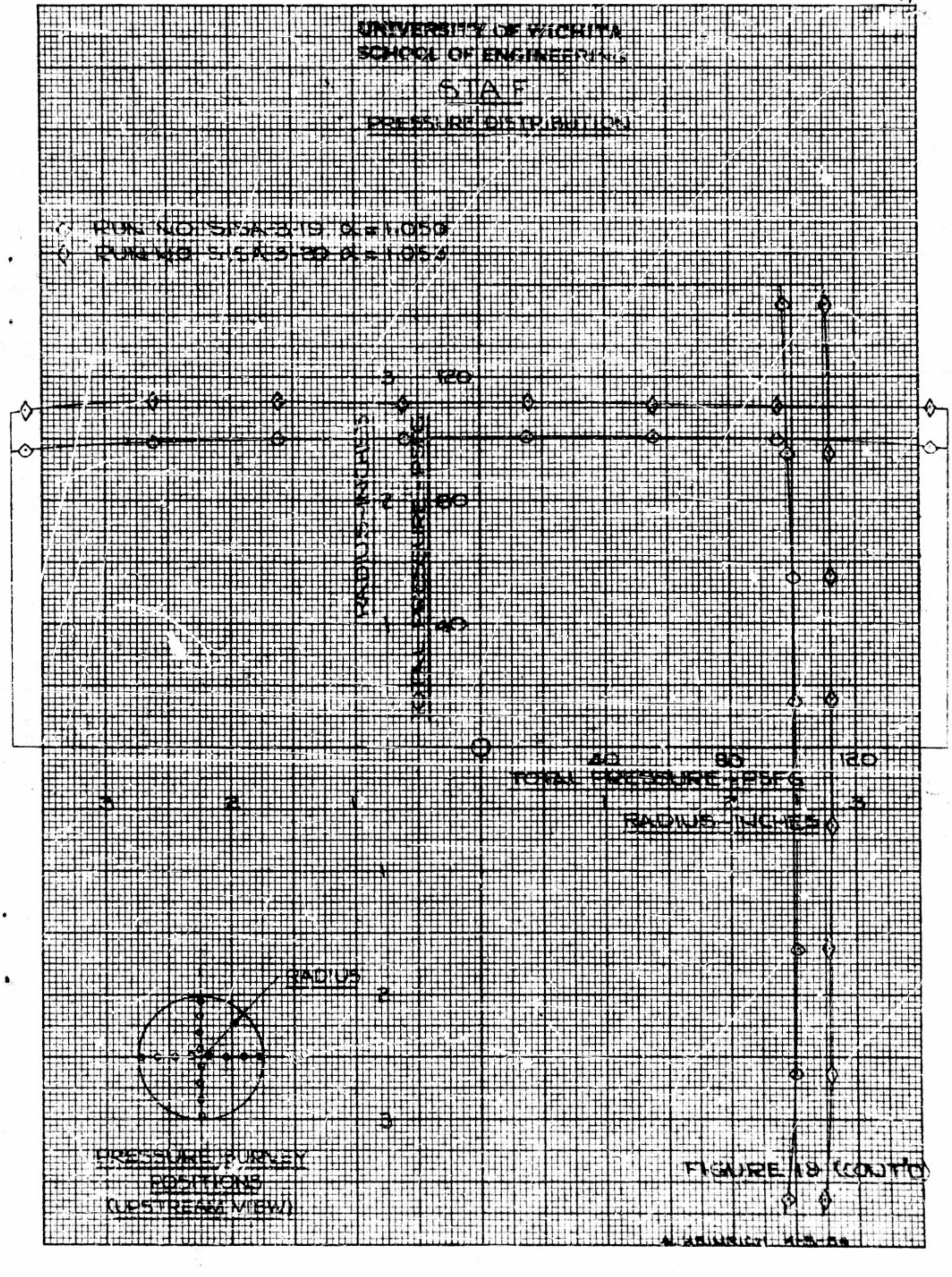


FIGURE 18 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA. A

PRESSURE DISTRIBUTION

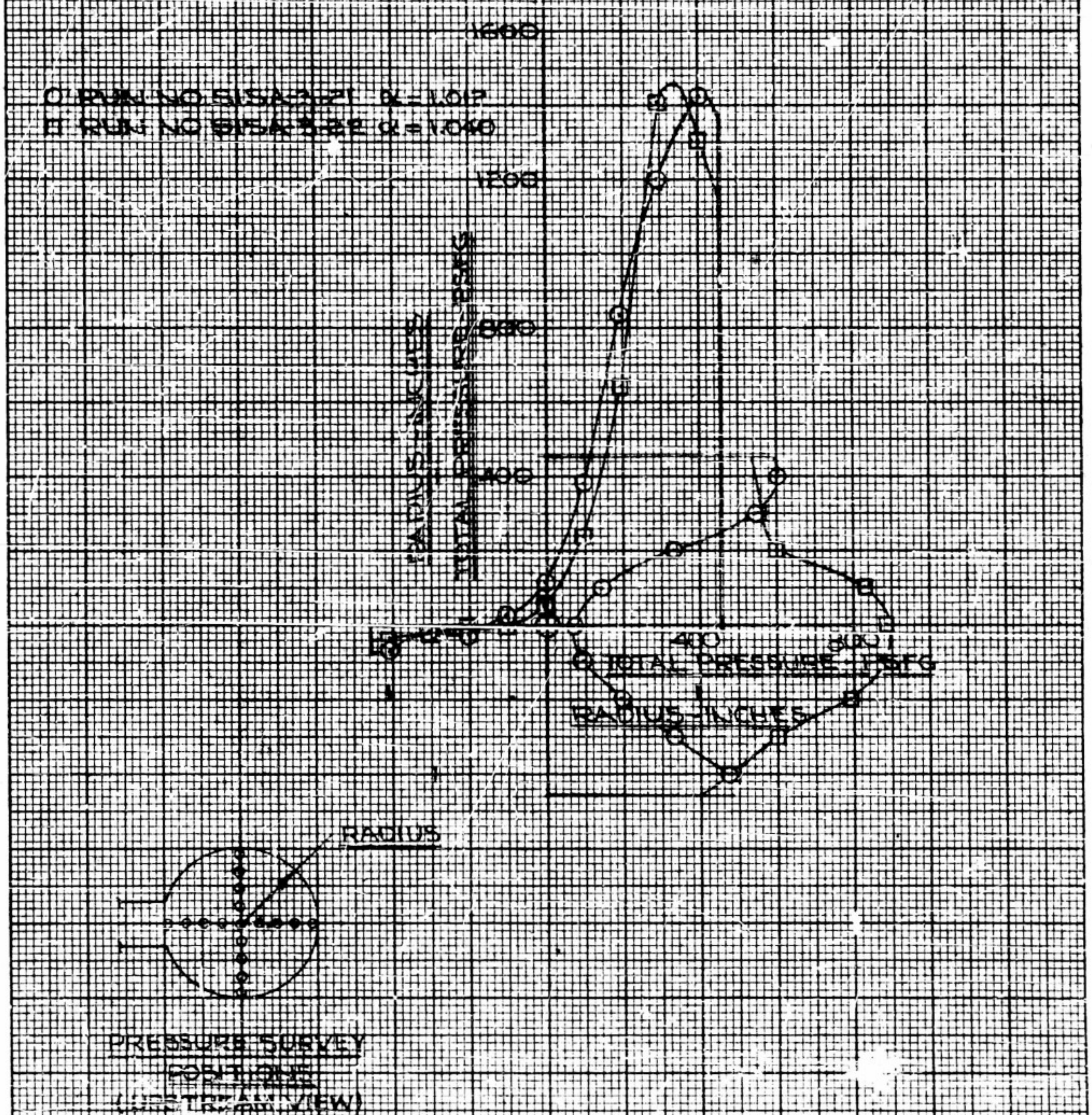


FIGURE 13 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA. B

PRESSURE DISTRIBUTION

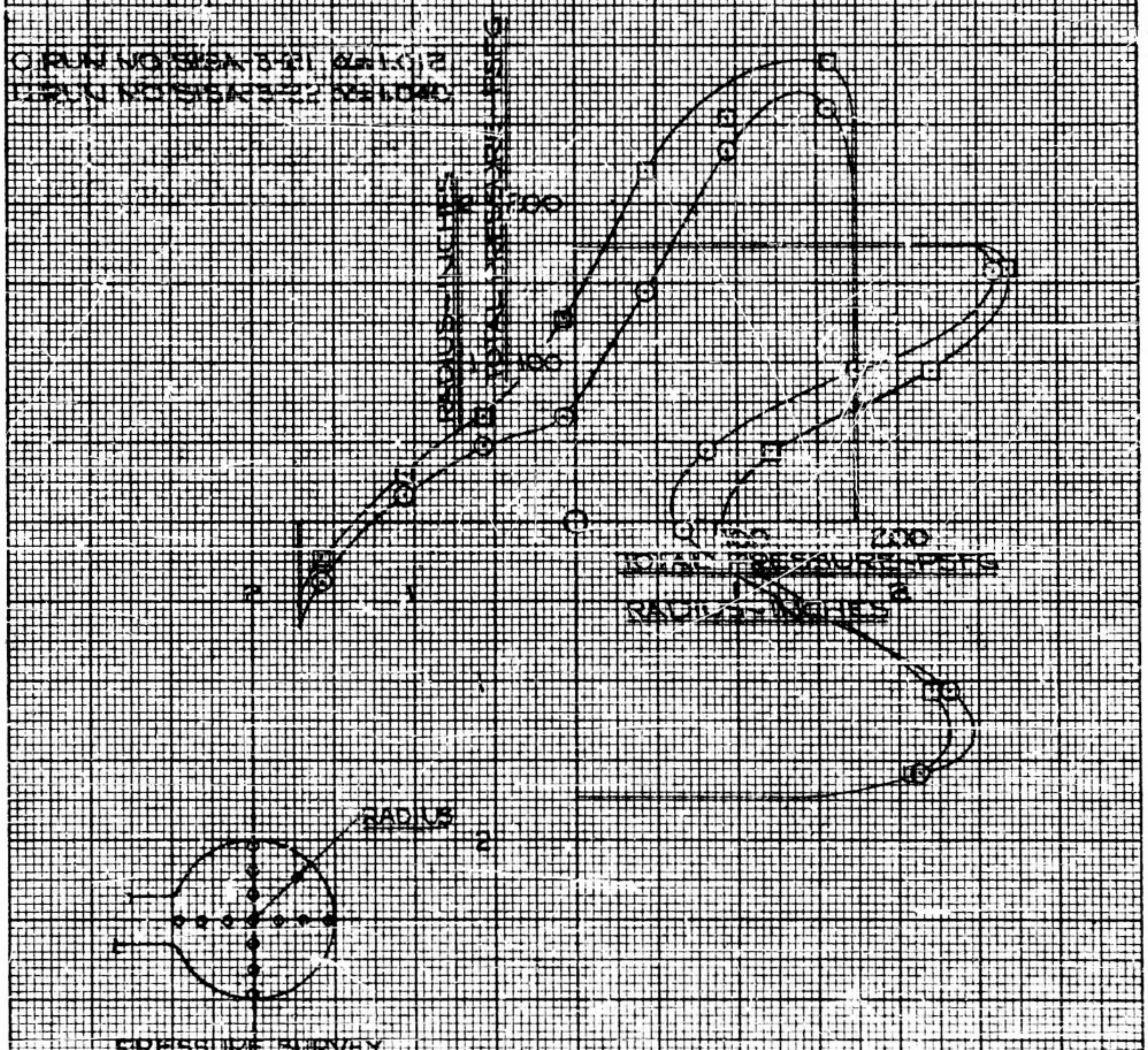


FIGURE 19 (CONT'D)

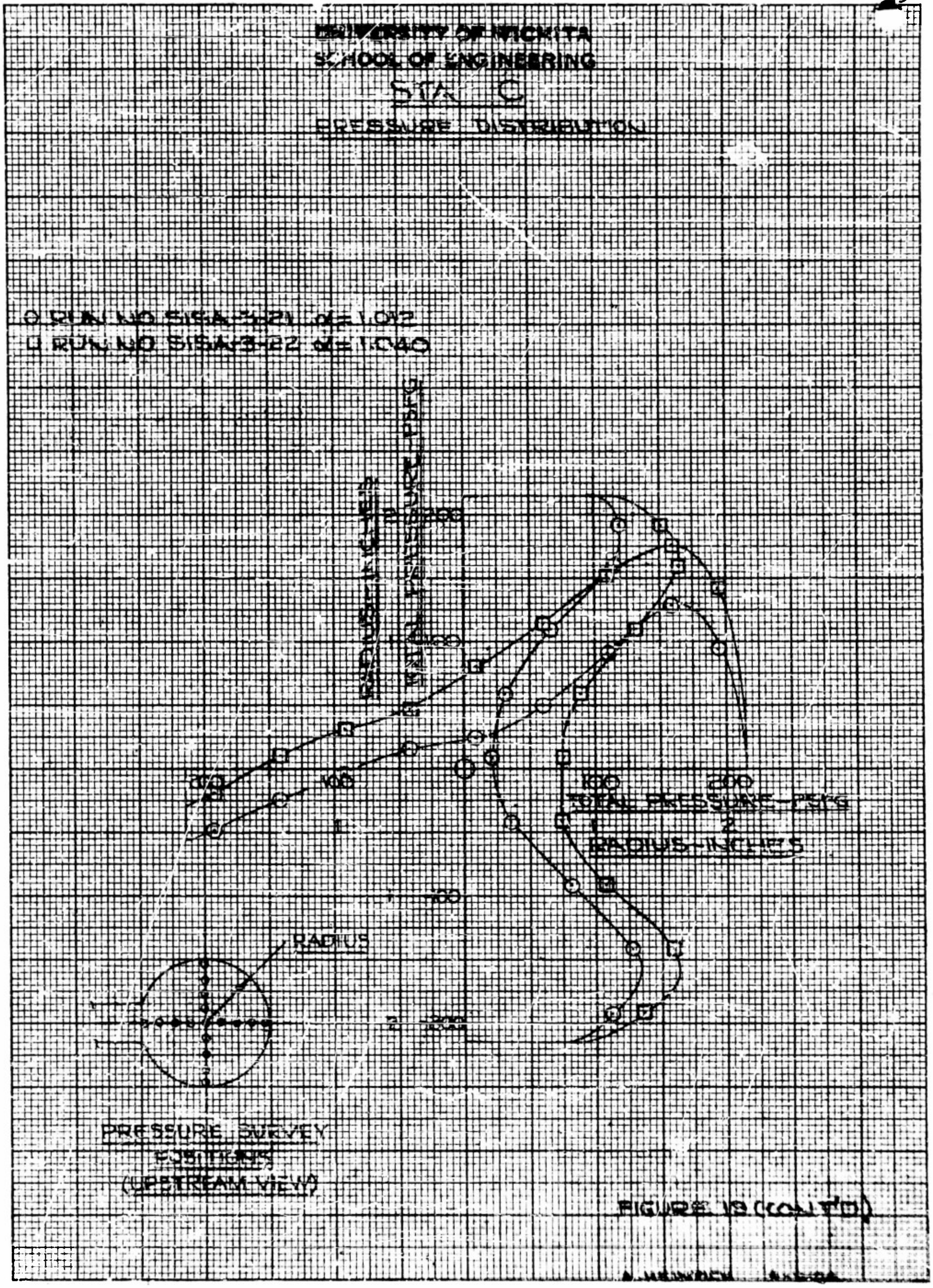


FIGURE 13 (CON'T'D)

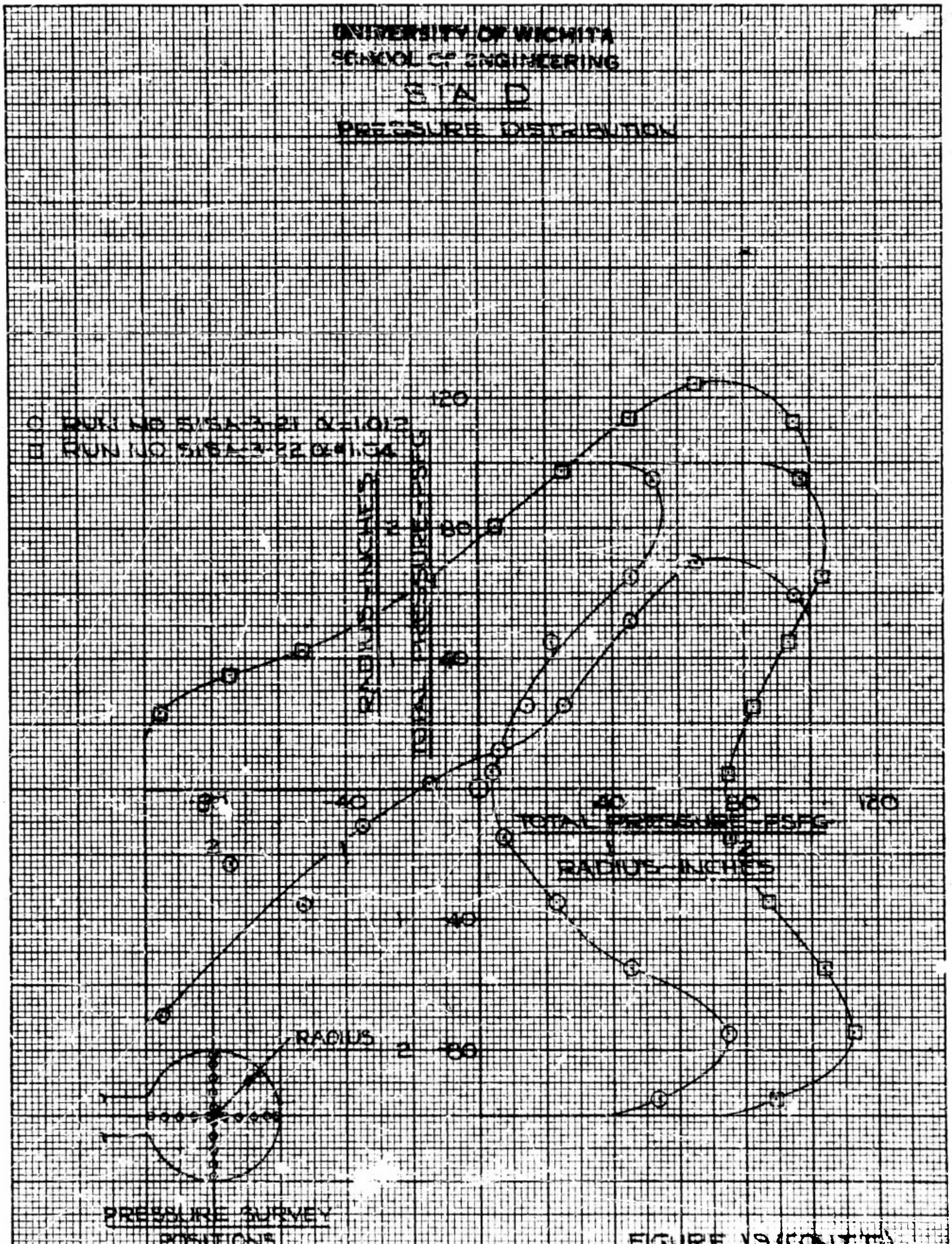


FIGURE 19 (CONT'D)

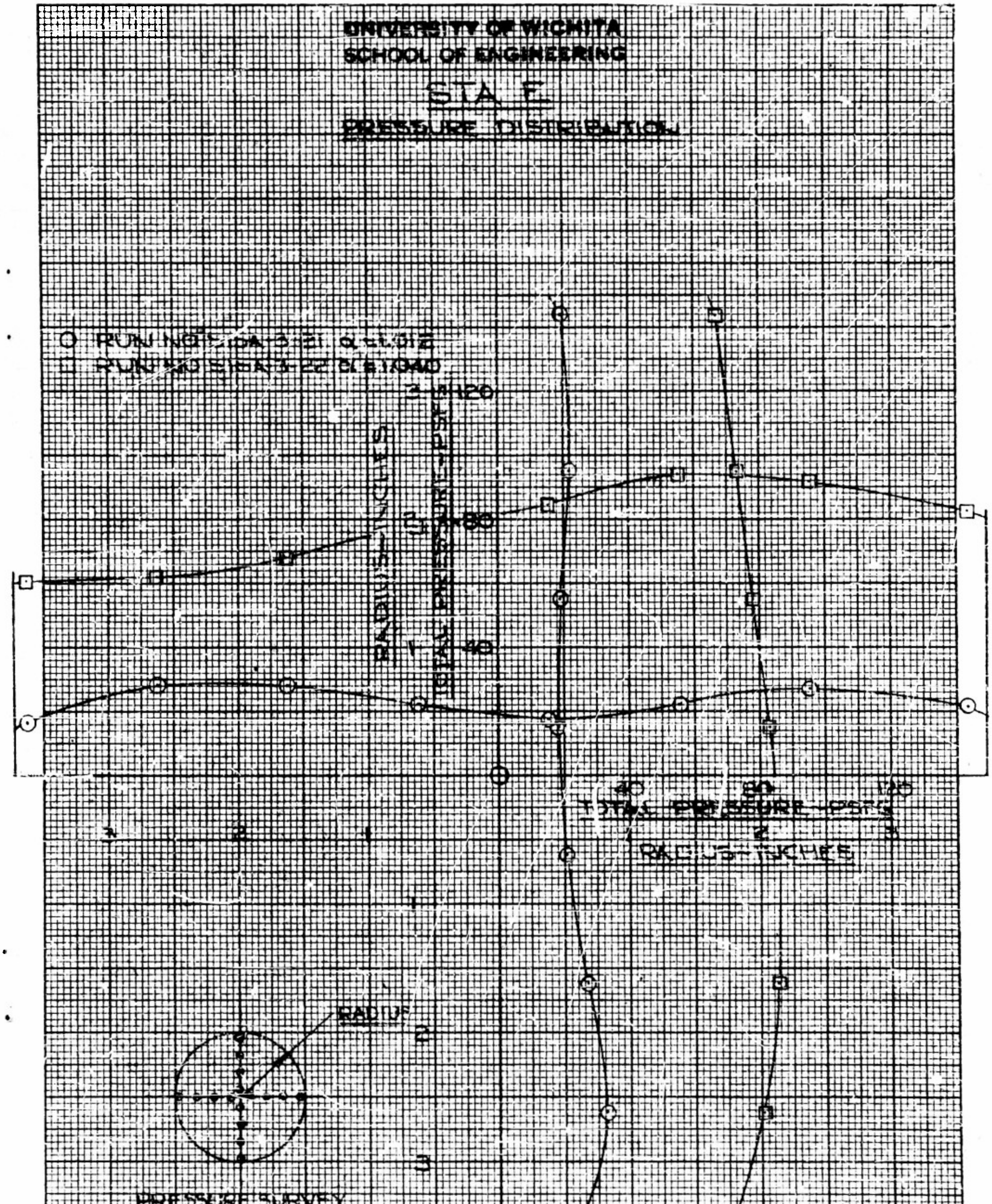


FIGURE 19 (CONT'D)

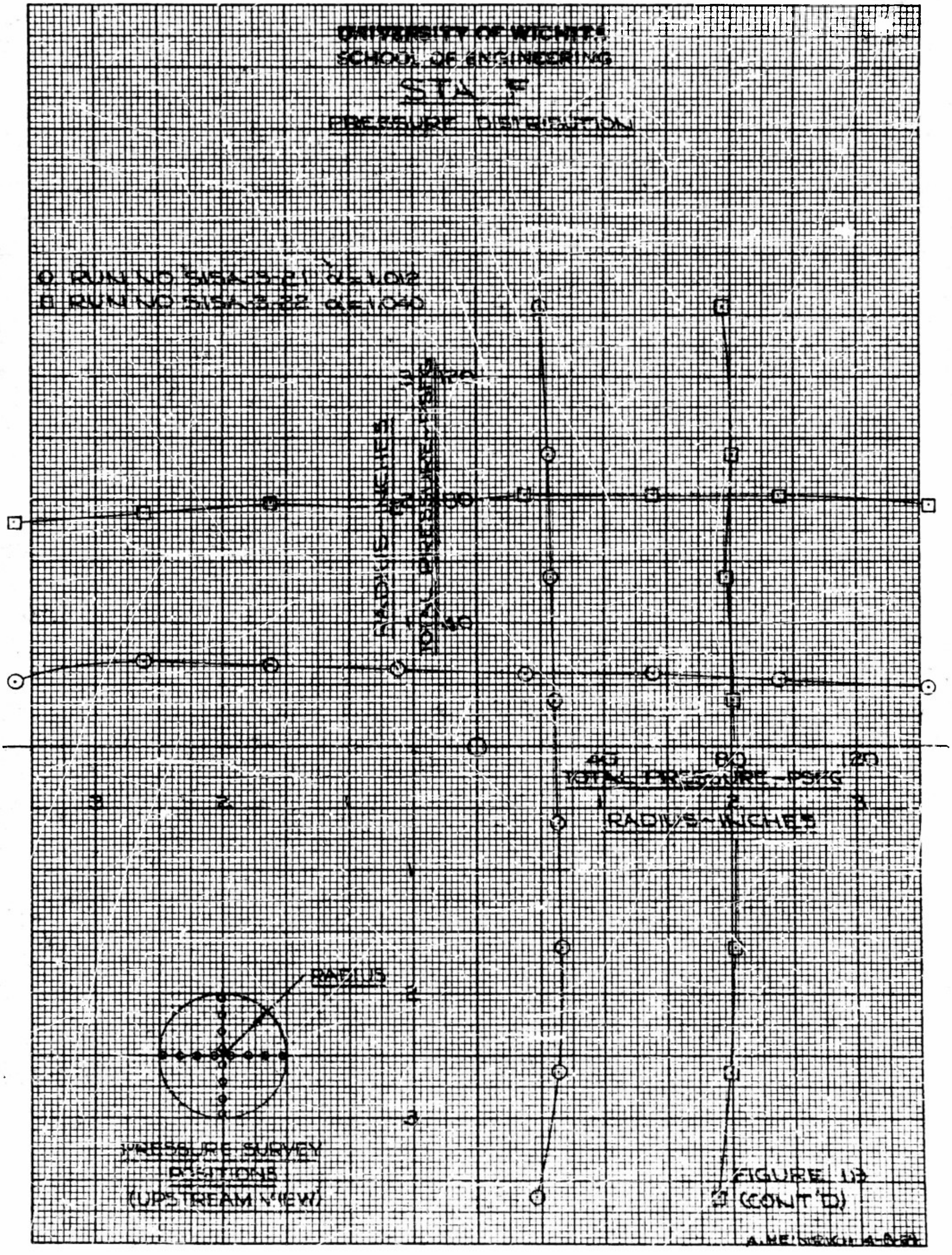


FIGURE 13
(CONT'D)

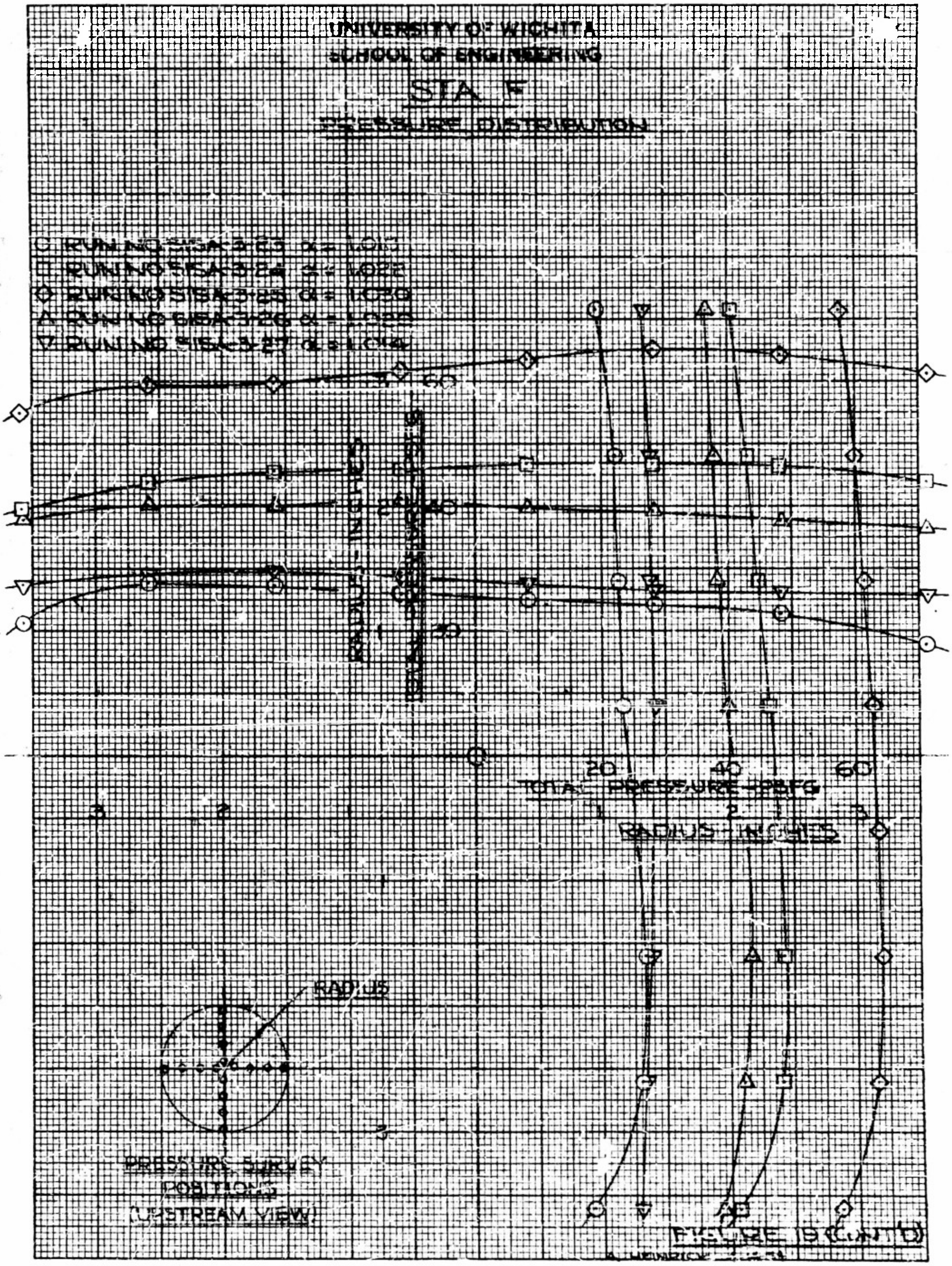


FIGURE 19 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA. A

PRESSURE DISTRIBUTION

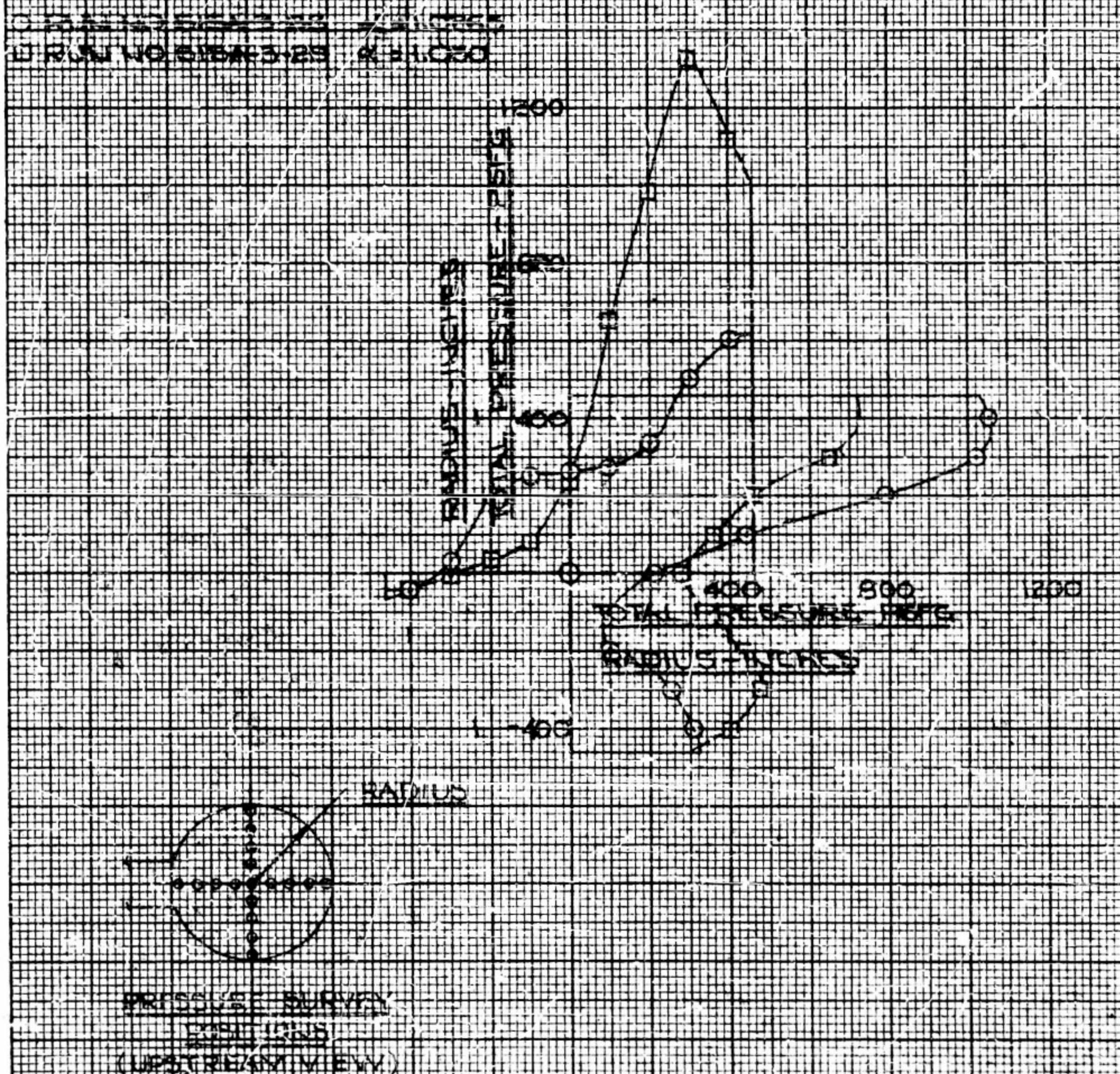


FIGURE 19 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA. B

PRESSURE DISTRIBUTION

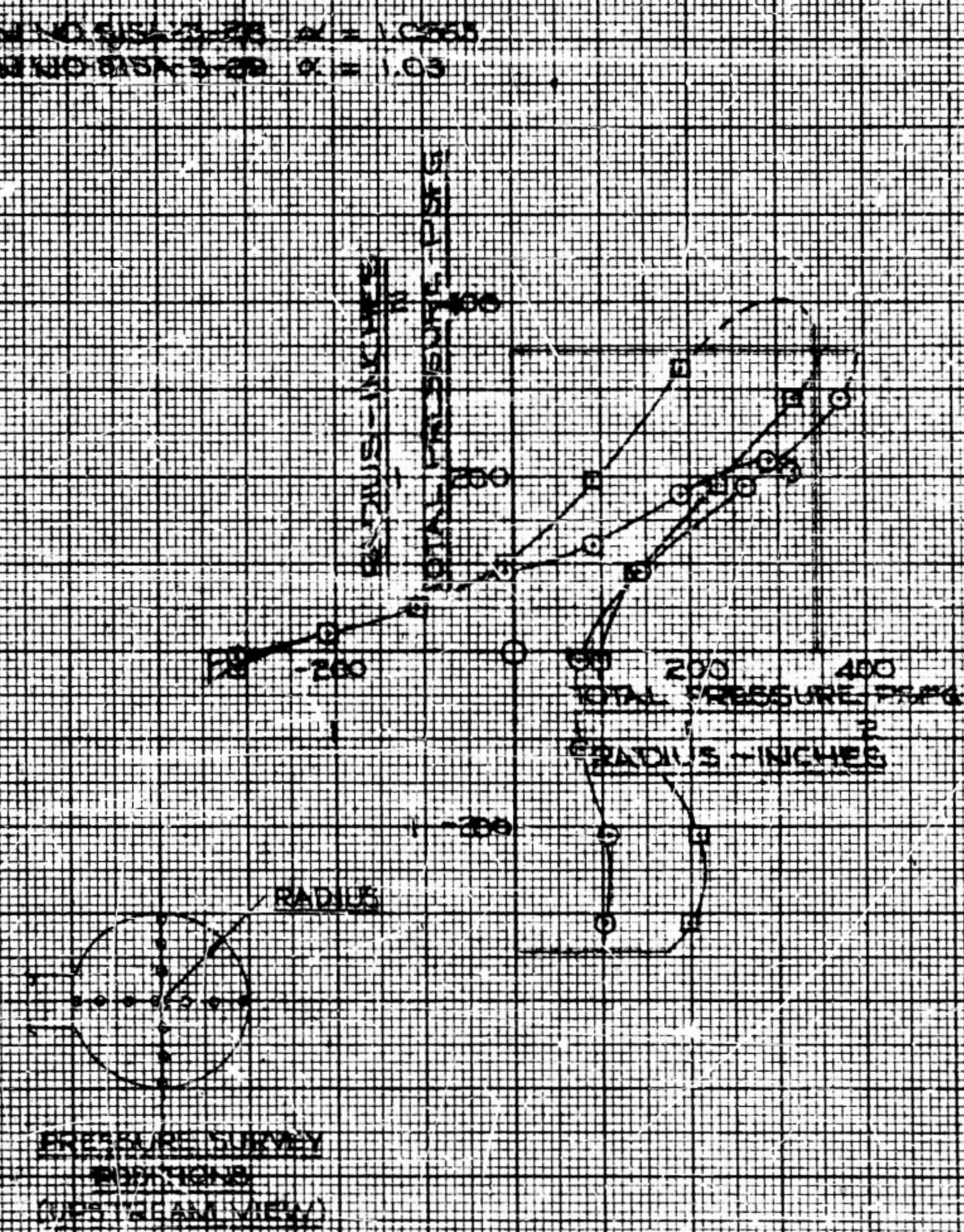


FIGURE 15 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA. C

PRESSURE DISTRIBUTION

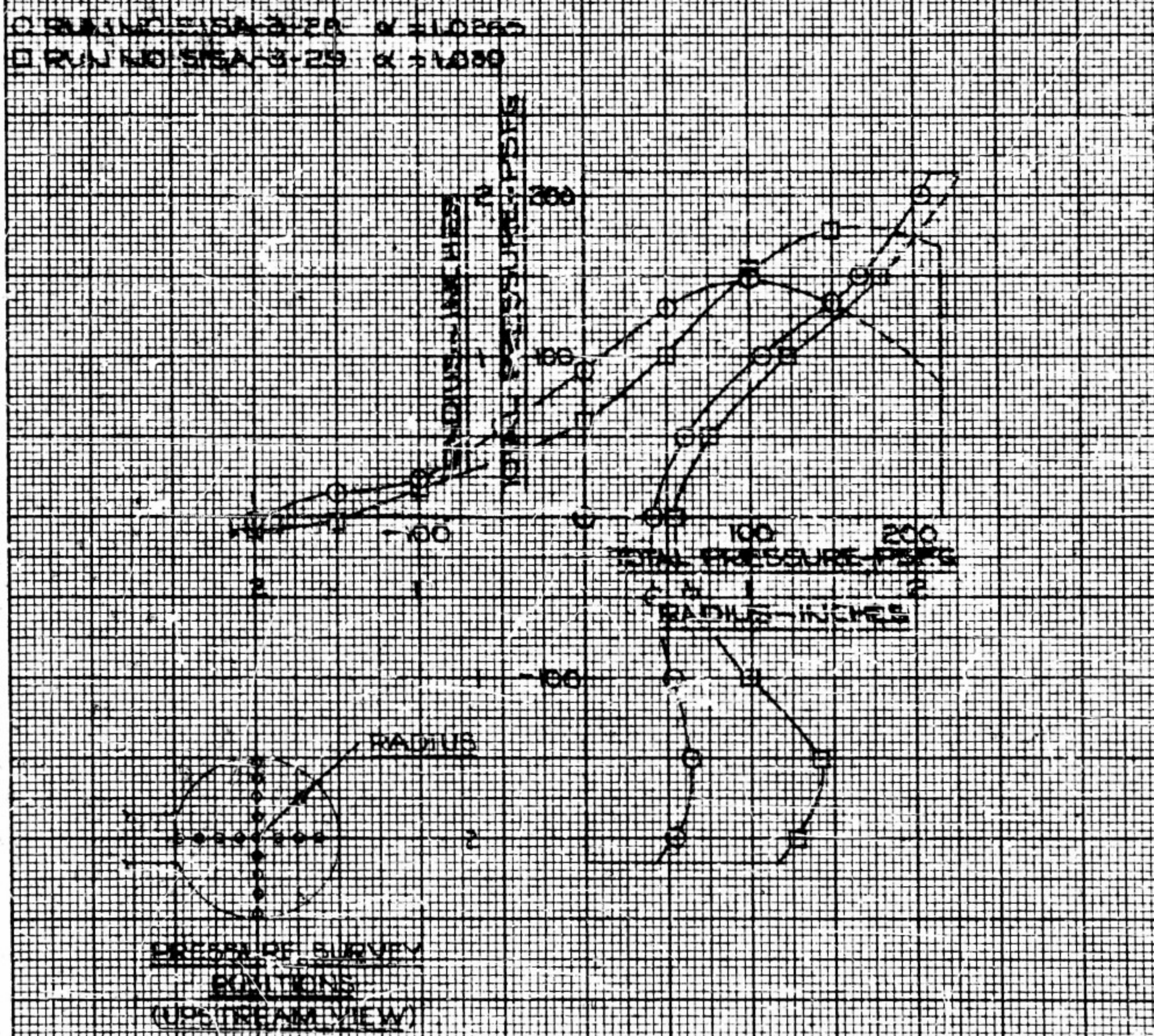


FIGURE 18 (CONT'D)

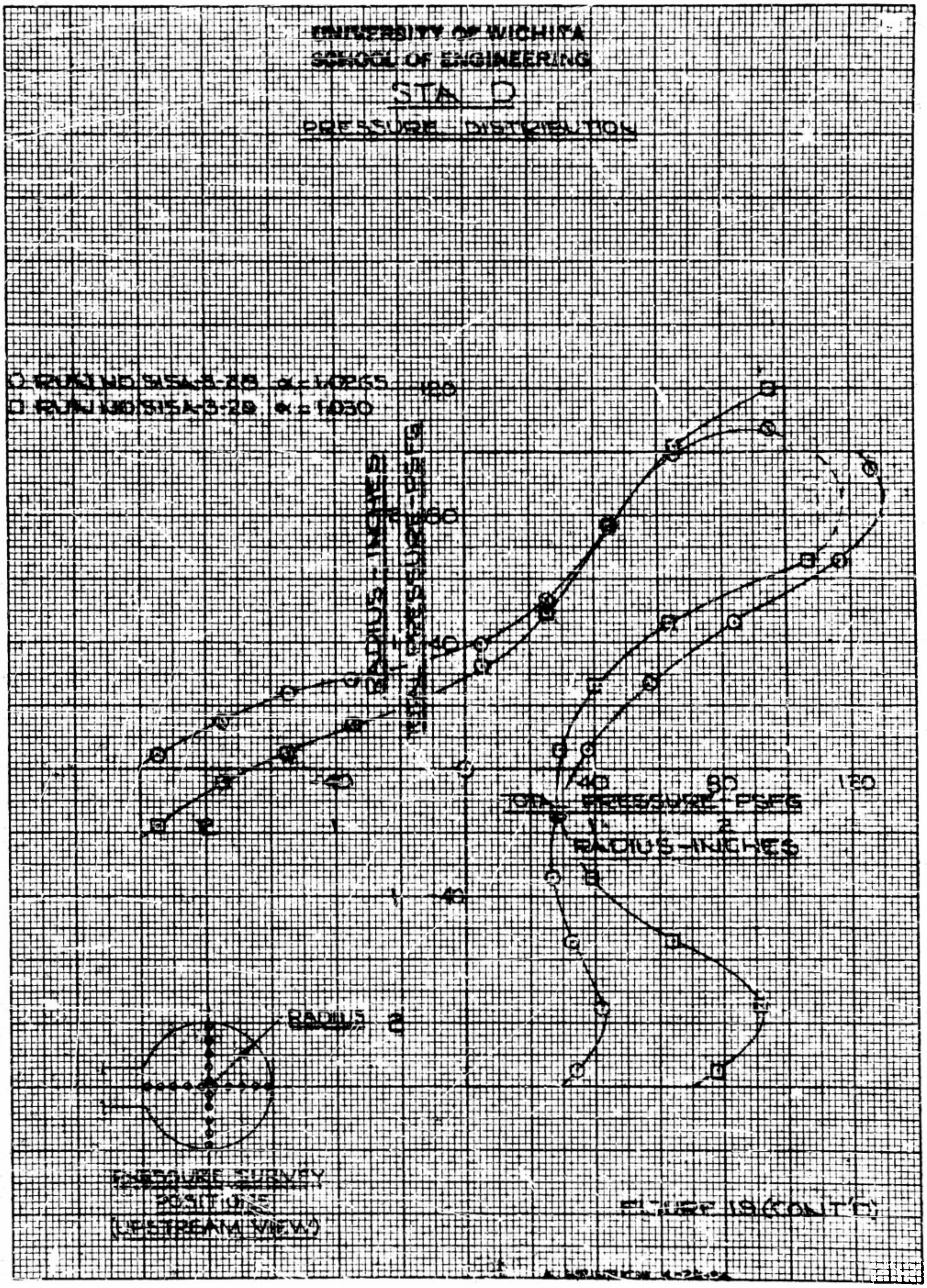


FIGURE 15 (CONT'D)

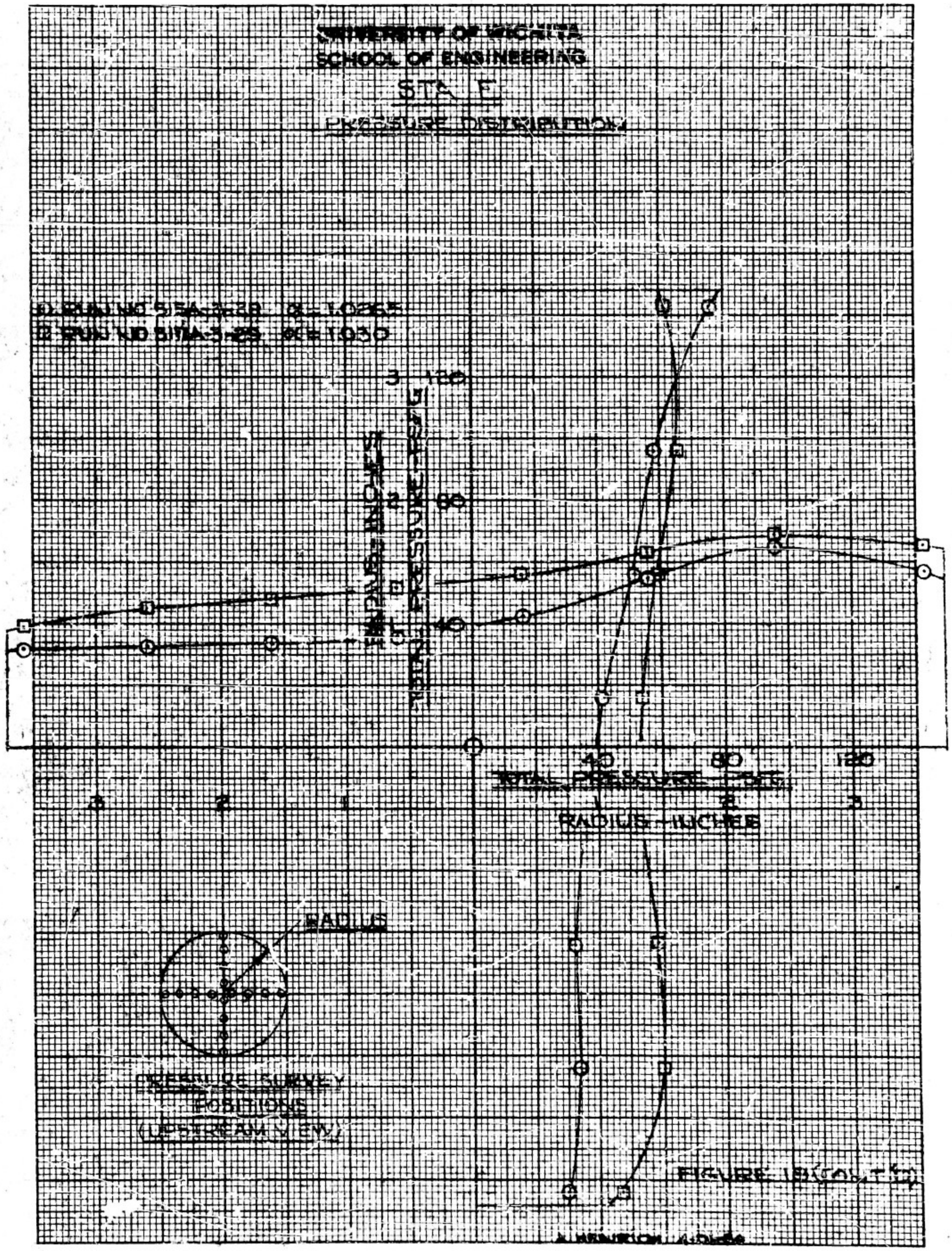


FIGURE 18 (CONT'D)

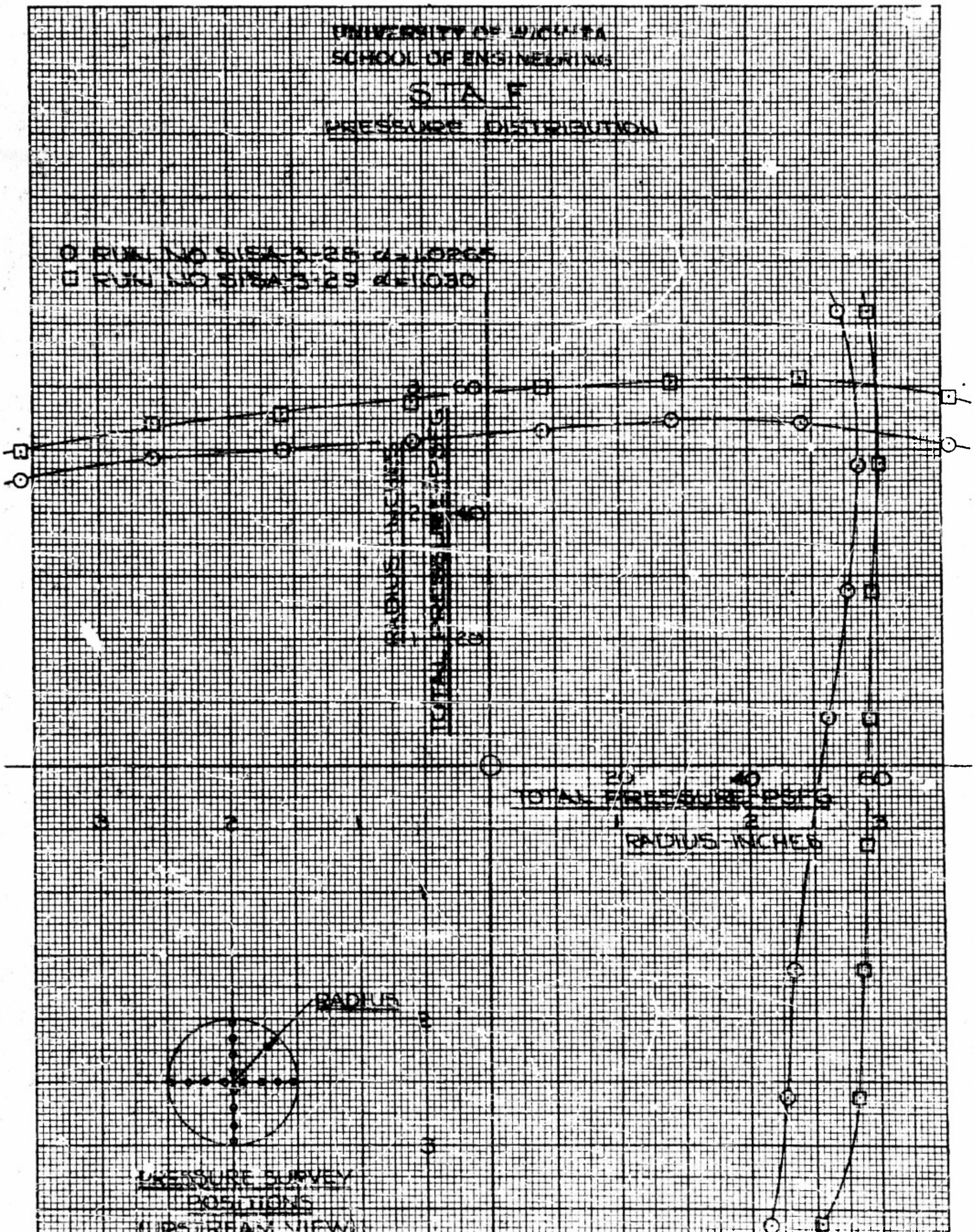


FIGURE 19 (CONC'D)

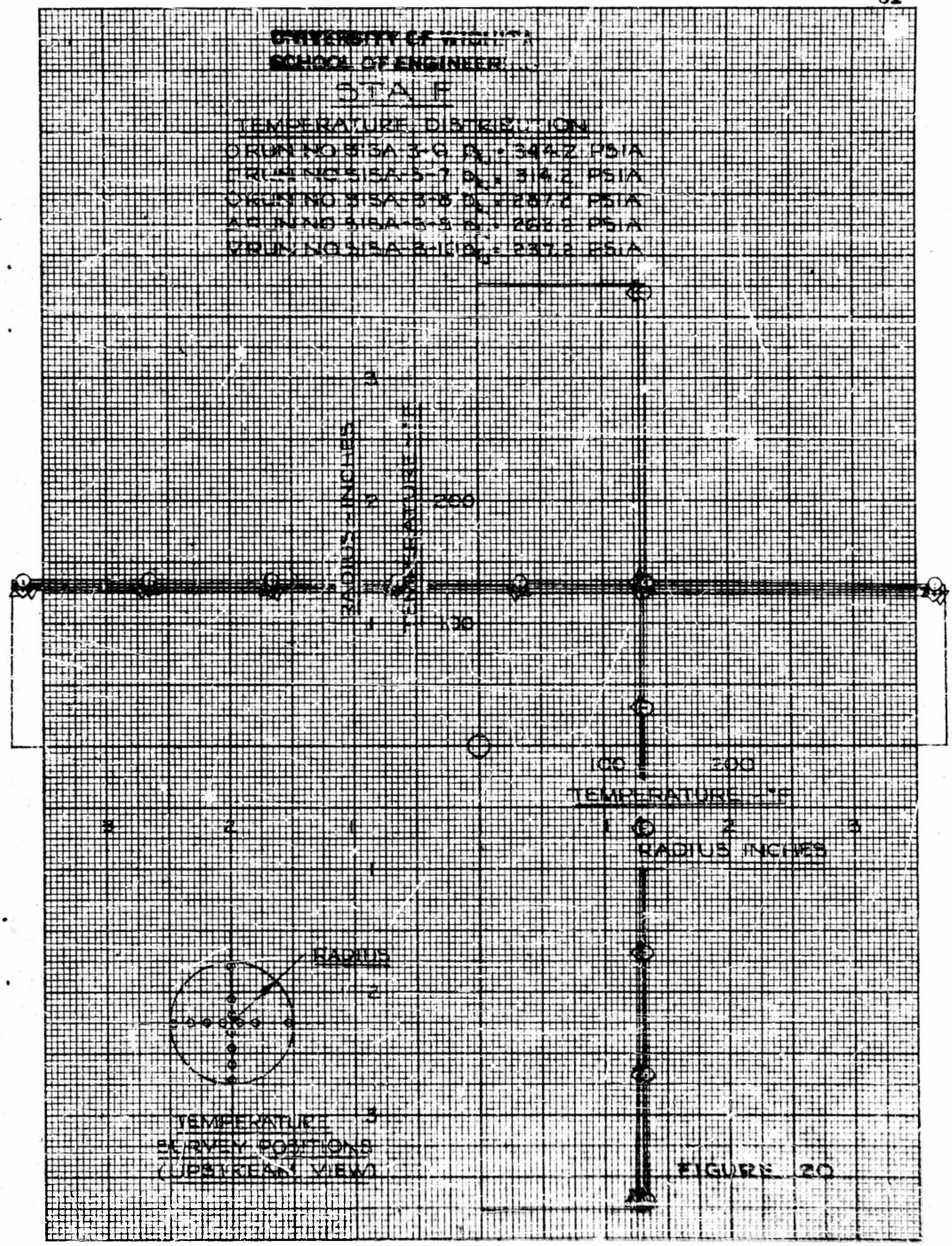

SCHOOL OF ENGINEERING
STAF
TEMPERATURE DISTRIBUTION
RUN NO 515A-3-9 = 344.2 PSIA
RUN NO 515A-3-7 = 314.2 PSIA
RUN NO 515A-3-8
RUN NO 515A-3-5
RUN NO 515A-3-10 = 237.2 PSIA
RADIUS - INCHES
TEMPERATURE - °F
100
200
TEMPERATURE - °F
RADIUS INCHES
3
2
1
1
2
3
RADIUS
TEMPERATURE
SURVEY POSITIONS
(UPSTREAM VIEW)

FIGURE 20

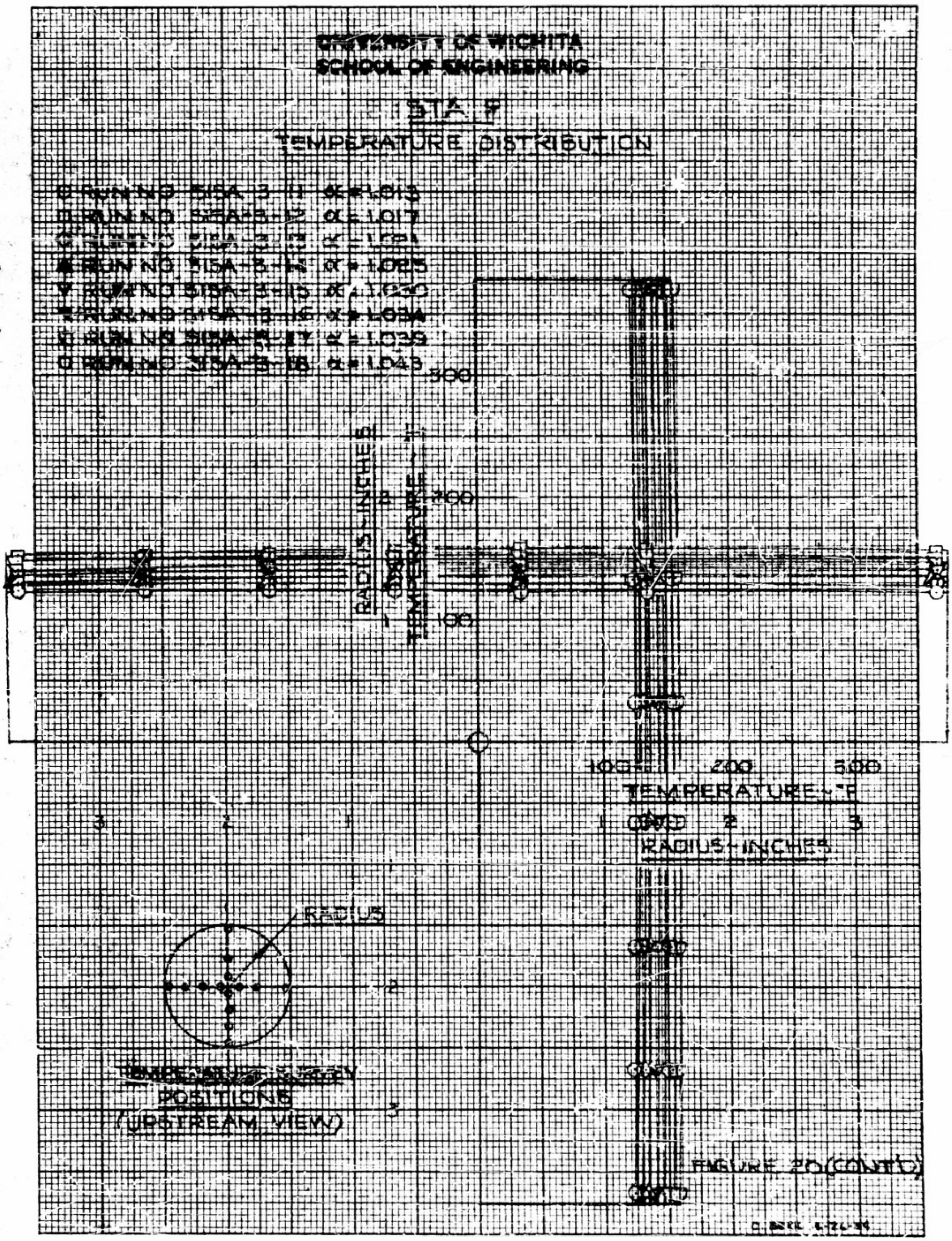


FIGURE 20 (CONT'D)

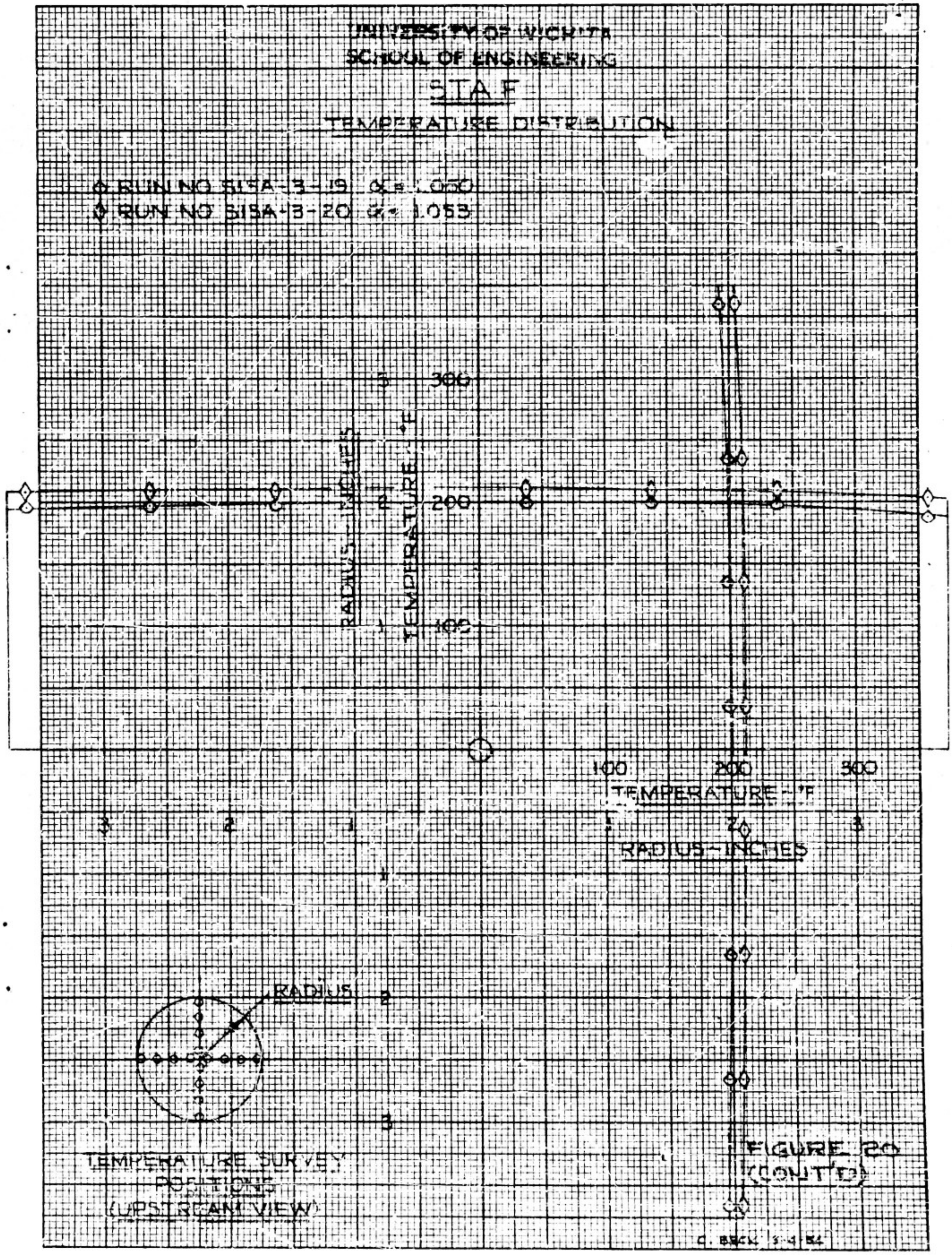


FIGURE 20 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA A

TEMPERATURE DISTRIBUTION

○ RUN NO 51BA-3-21 α = 1.012
□ RUN NO 51BA-3-22 α = [illegible]

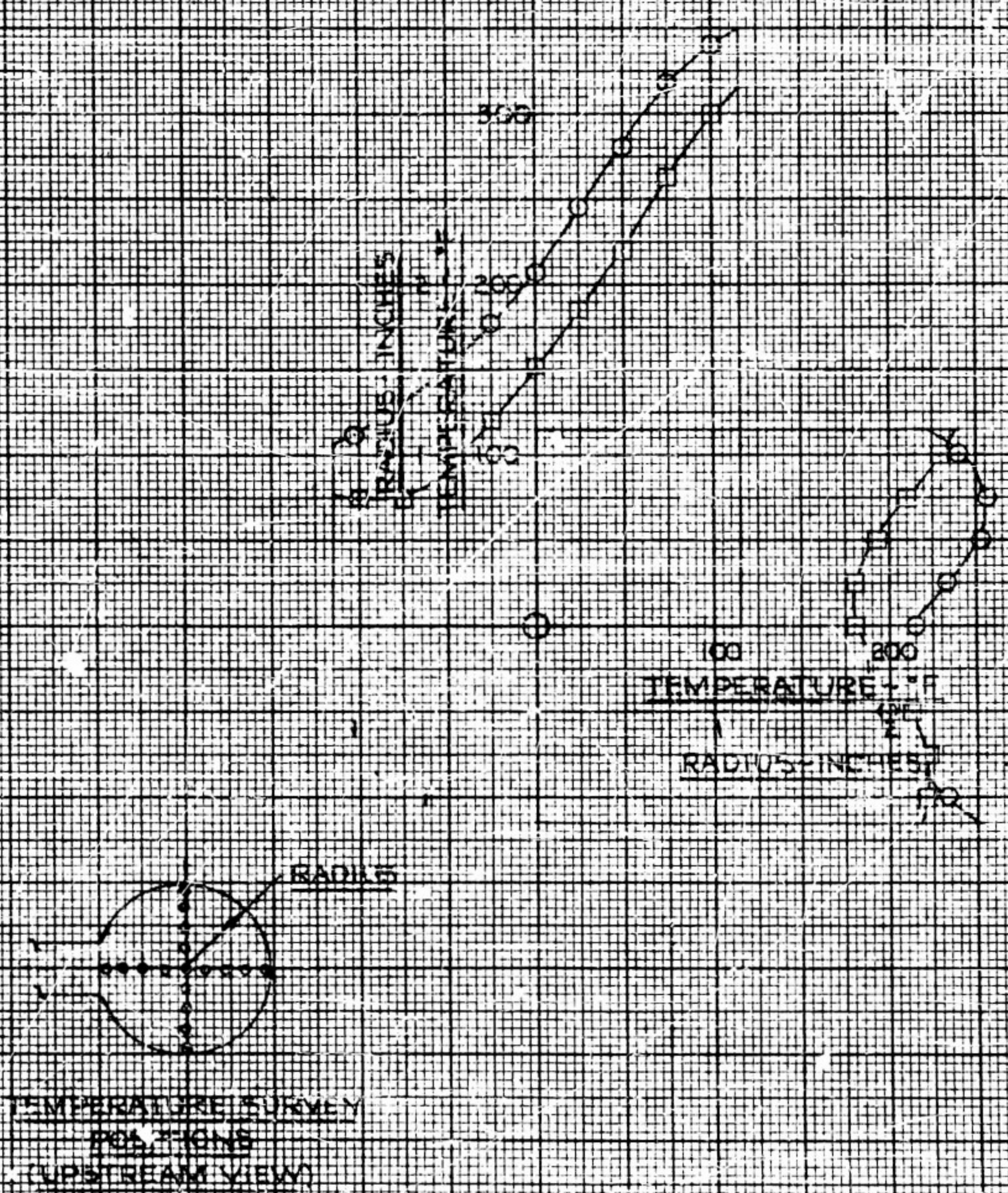


FIGURE 20 (CONT'D)

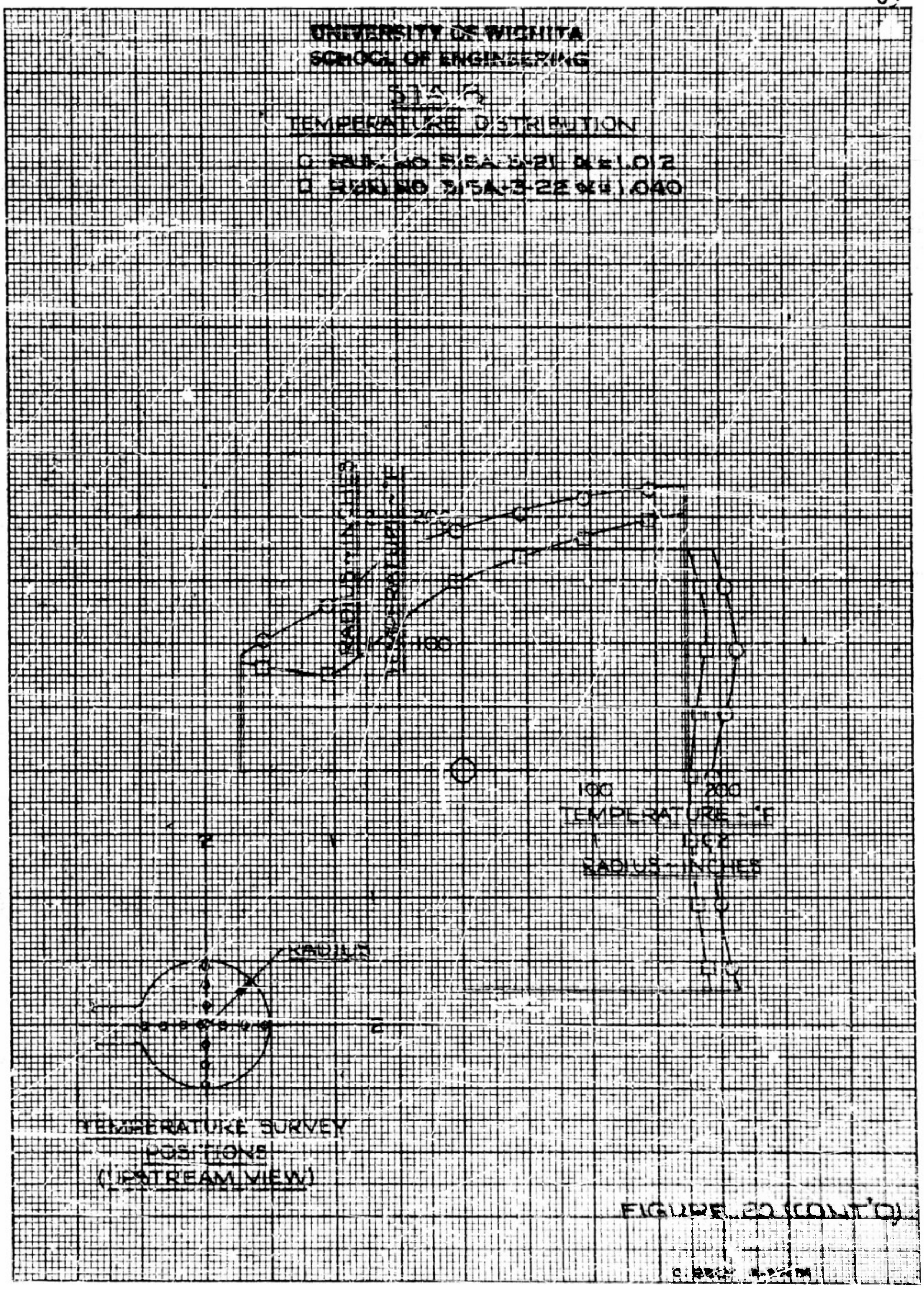


FIGURE 20 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA C

TEMPERATURE DISTRIBUTION

○ RUN NO 515A-3-21 α=1.012
□ RUN NO 515A-3-22 α=1.040

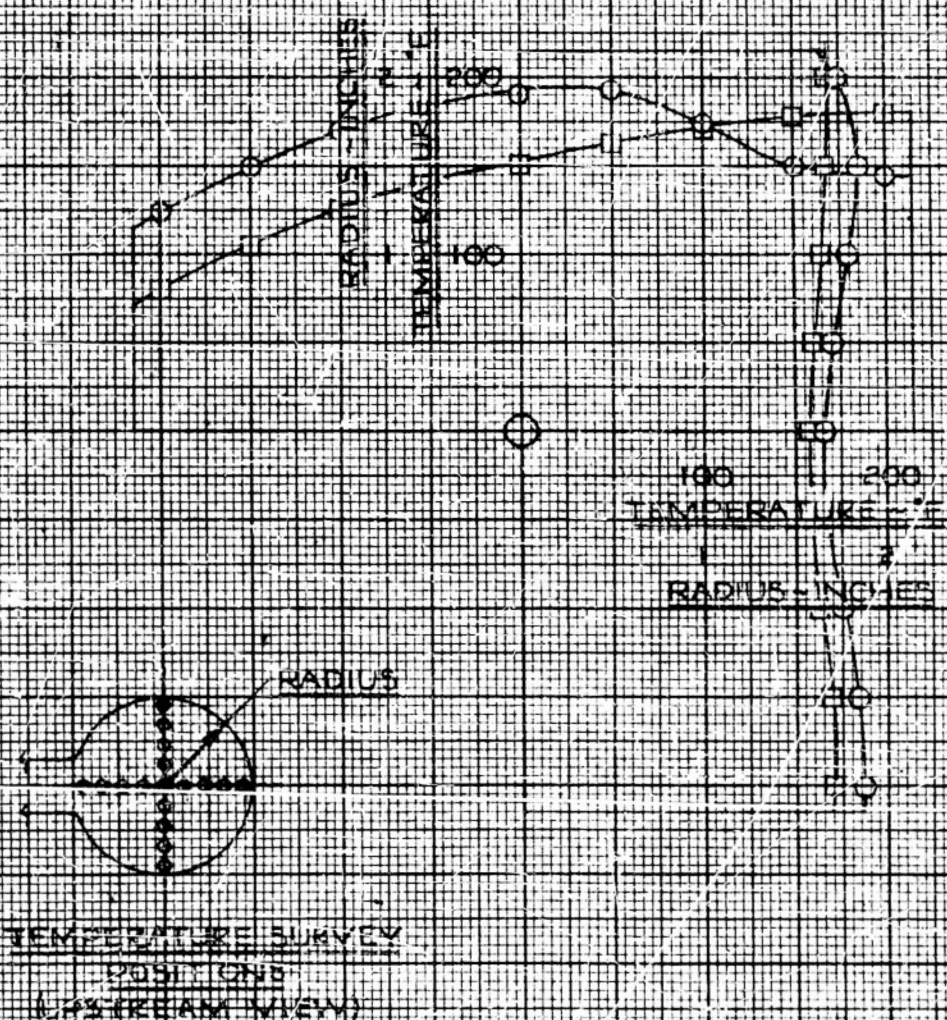


FIGURE 20 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA D

TEMPERATURE DISTRIBUTION

○ RUN NO 515A-3-21 Φ=1.012
□ RUN NO 515A-3-22 Φ=1.040

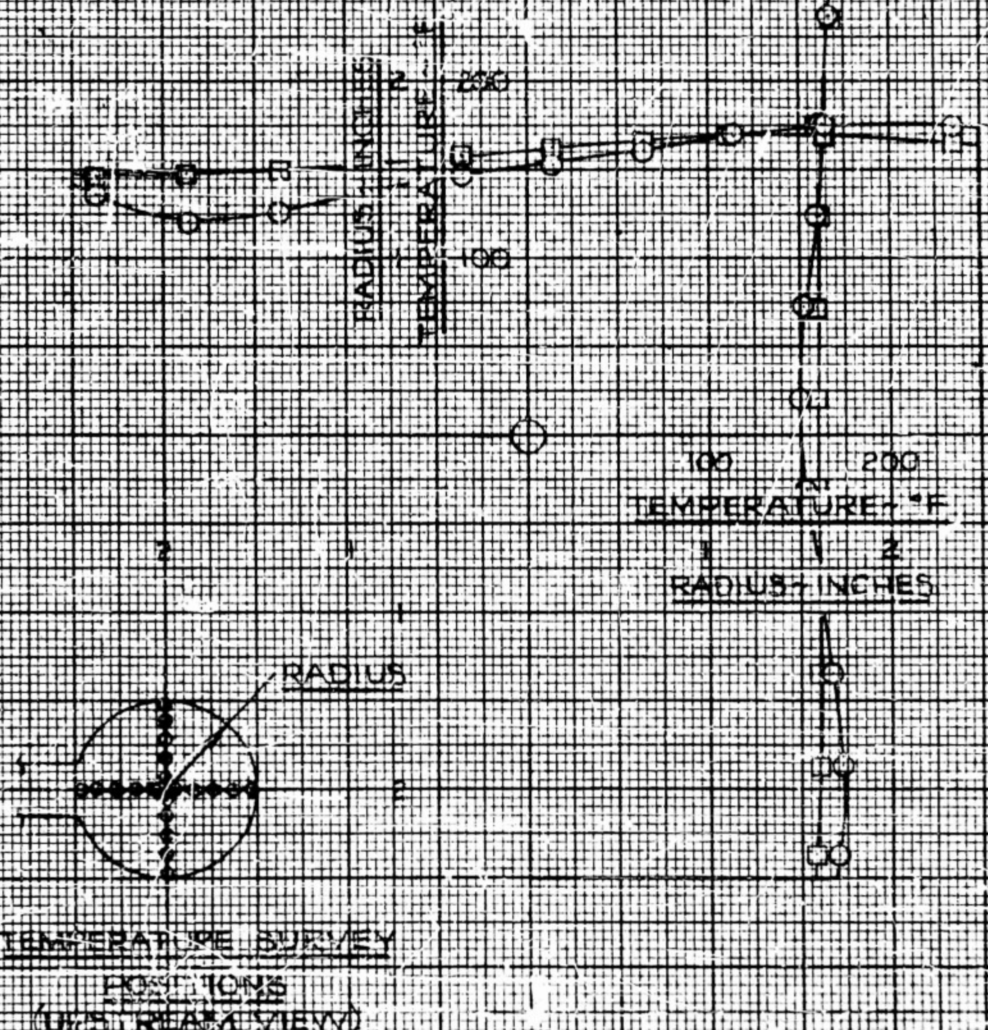


FIGURE 20 (CONT'D)

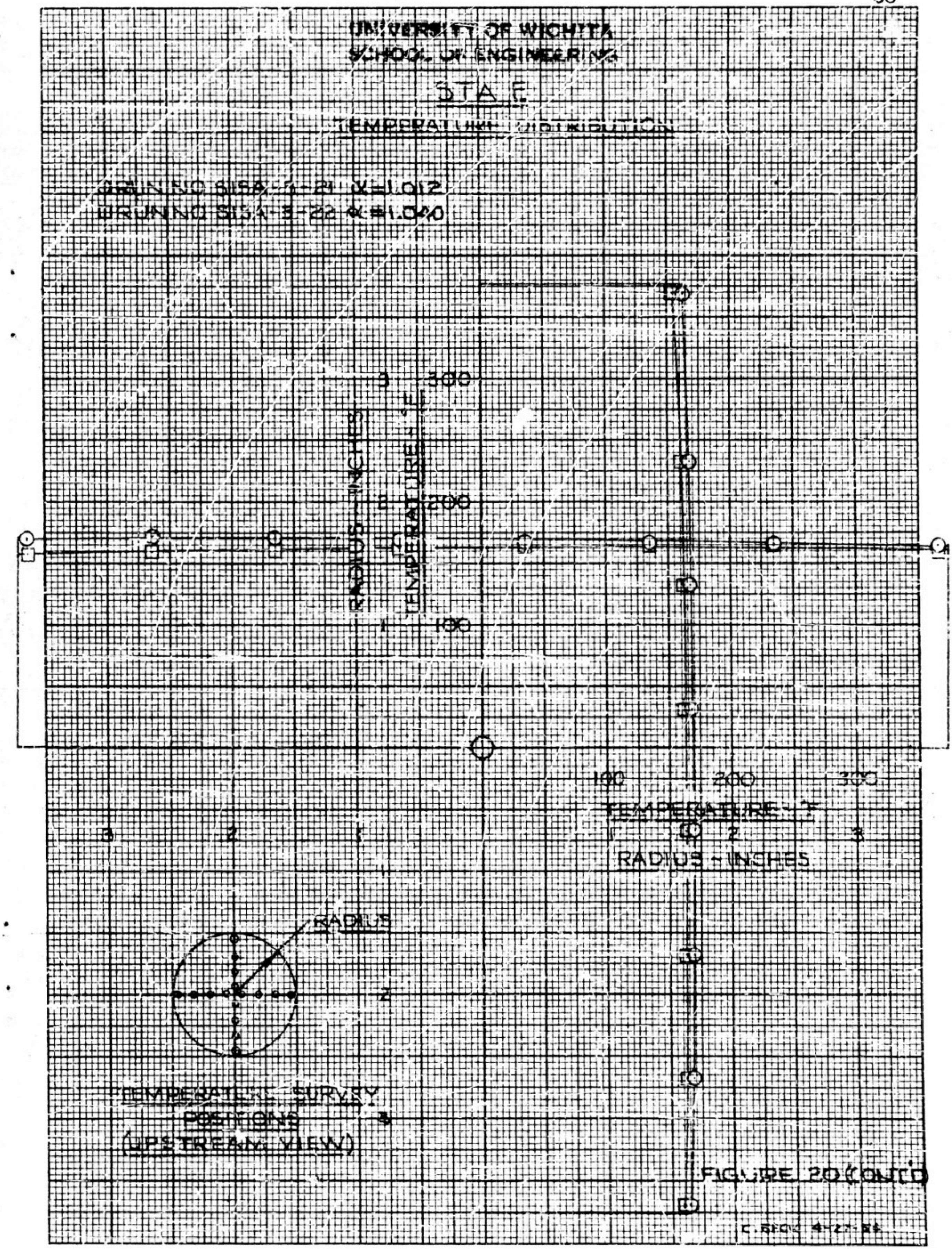


FIGURE 20 (CONT'D)

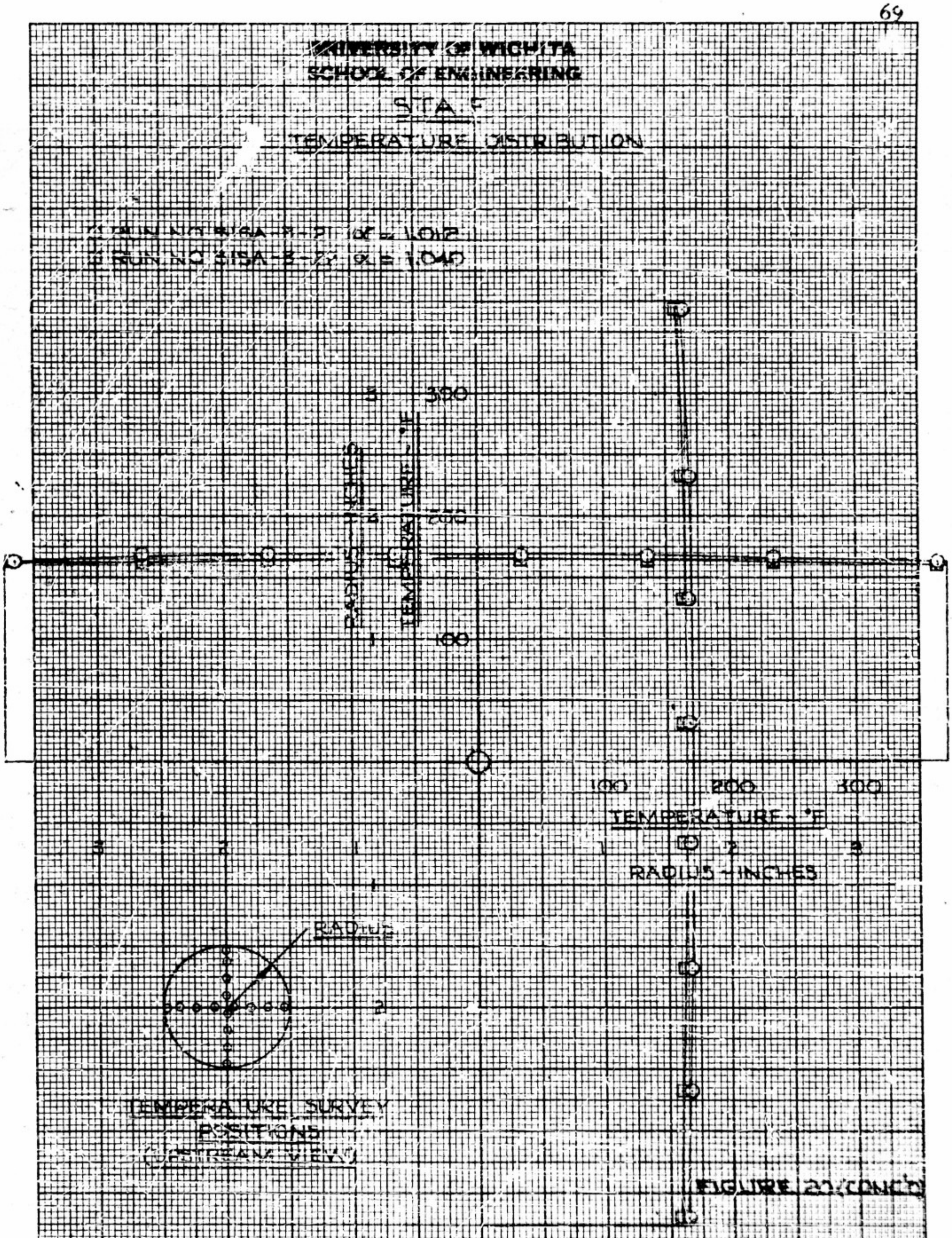


FIGURE 20 (CONC'D)

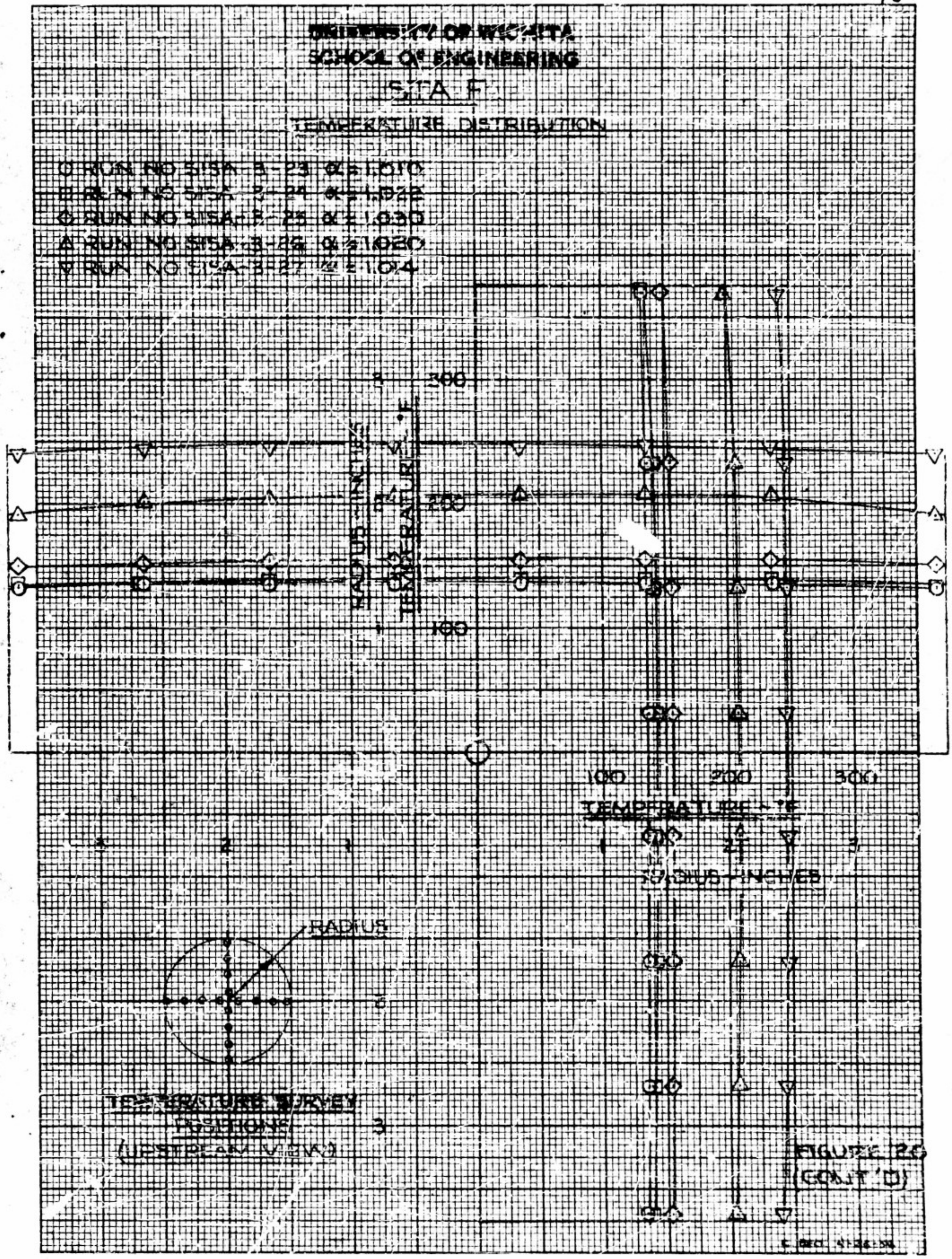


FIGURE 20
(CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STA A

TEMPERATURE DISTRIBUTION

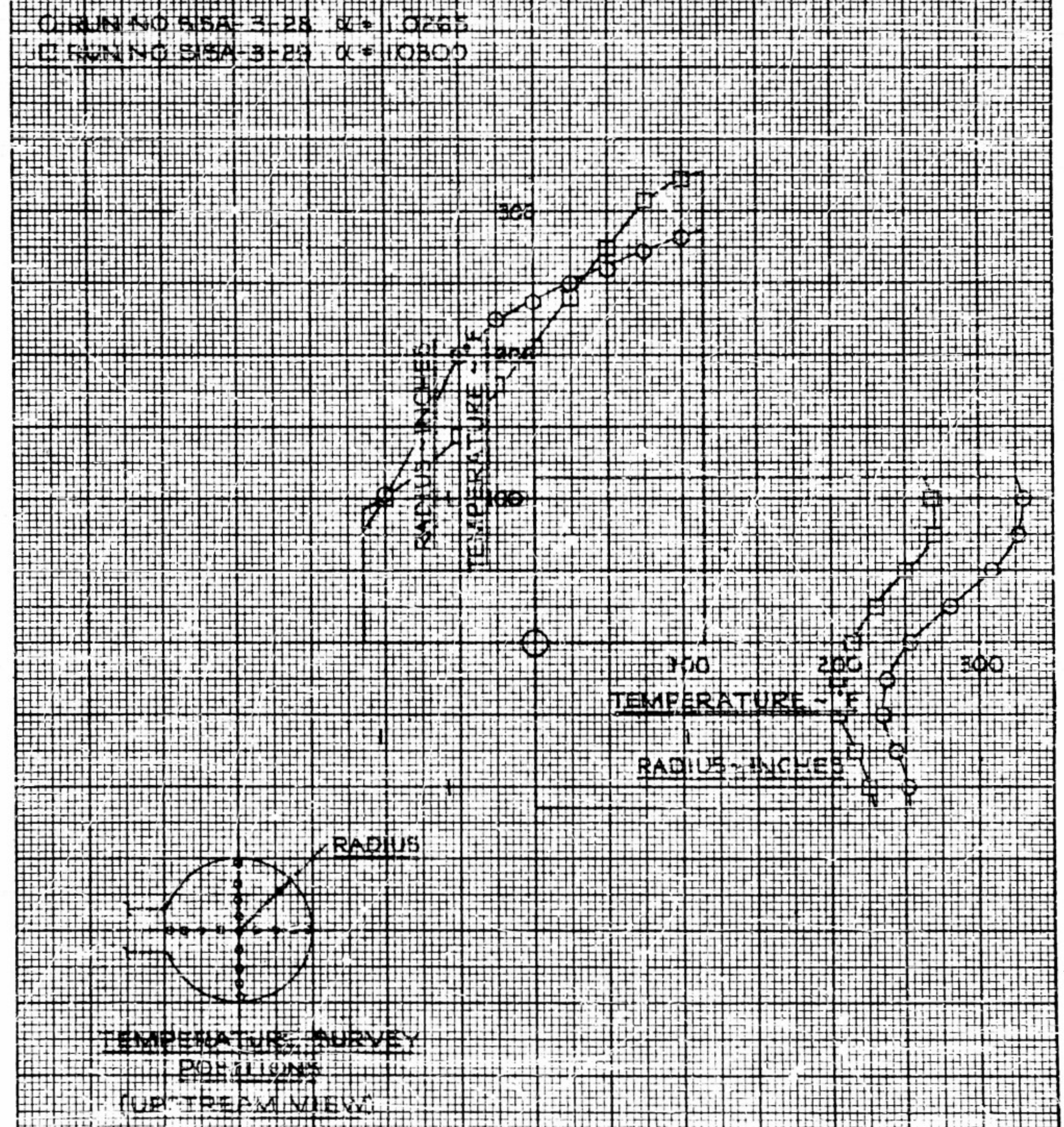


FIGURE 20 (CONT'D)

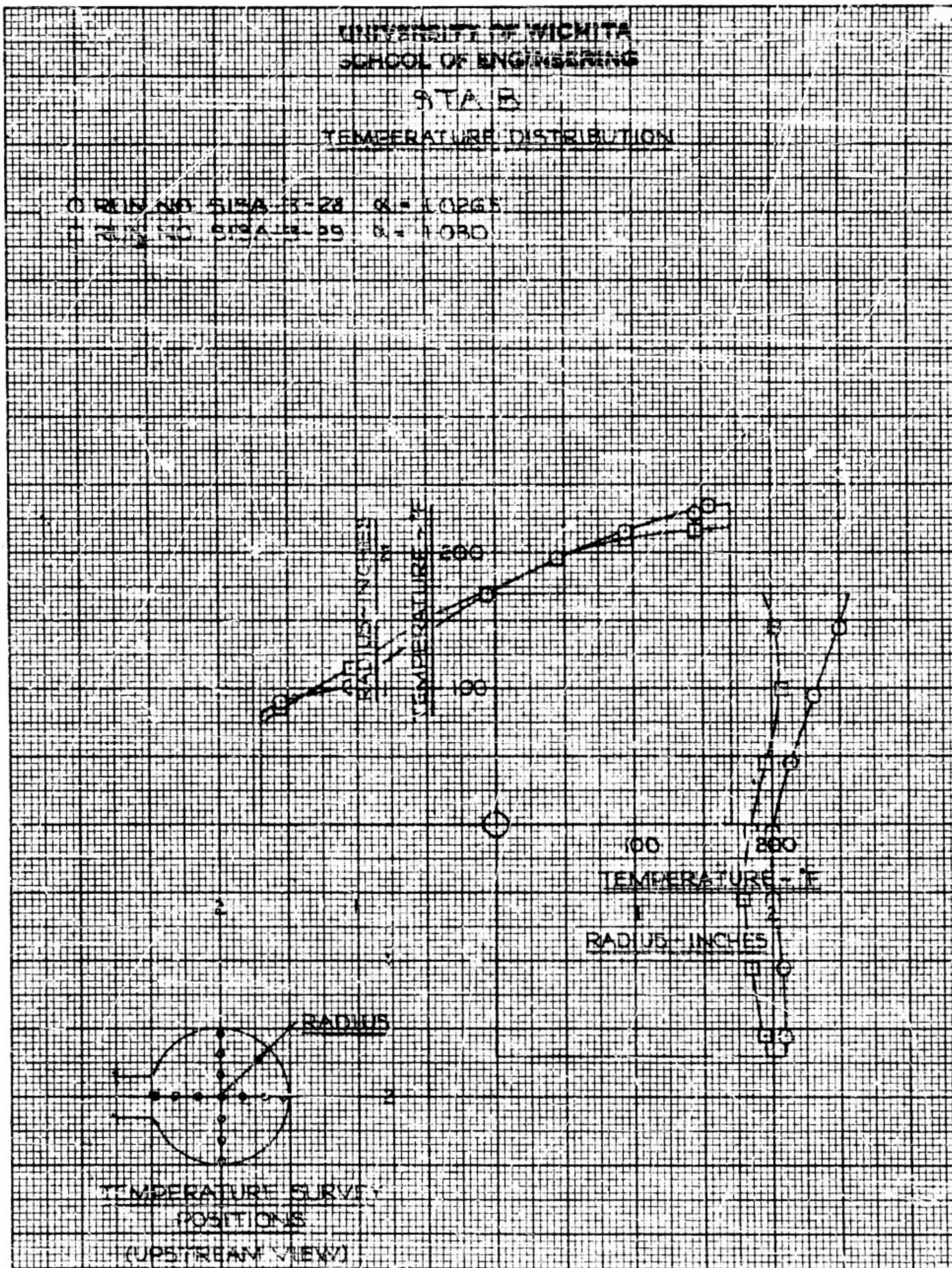


FIGURE 20 (CONT'D)

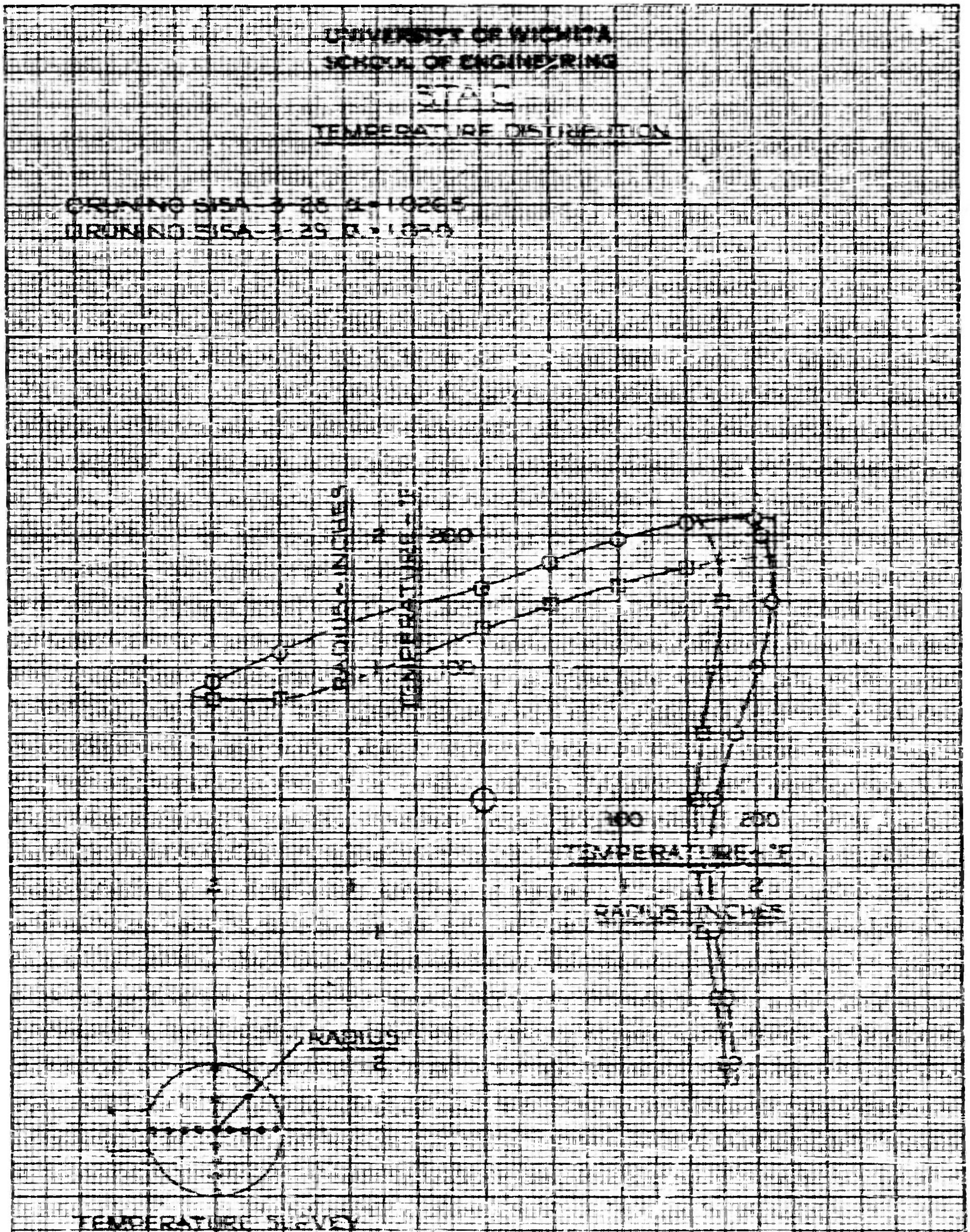


FIGURE 20 (CONT'D)

UNIVERSITY OF WICHITA
SCHOOL OF ENGINEERING

STAD

TEMPERATURE DISTRIBUTION

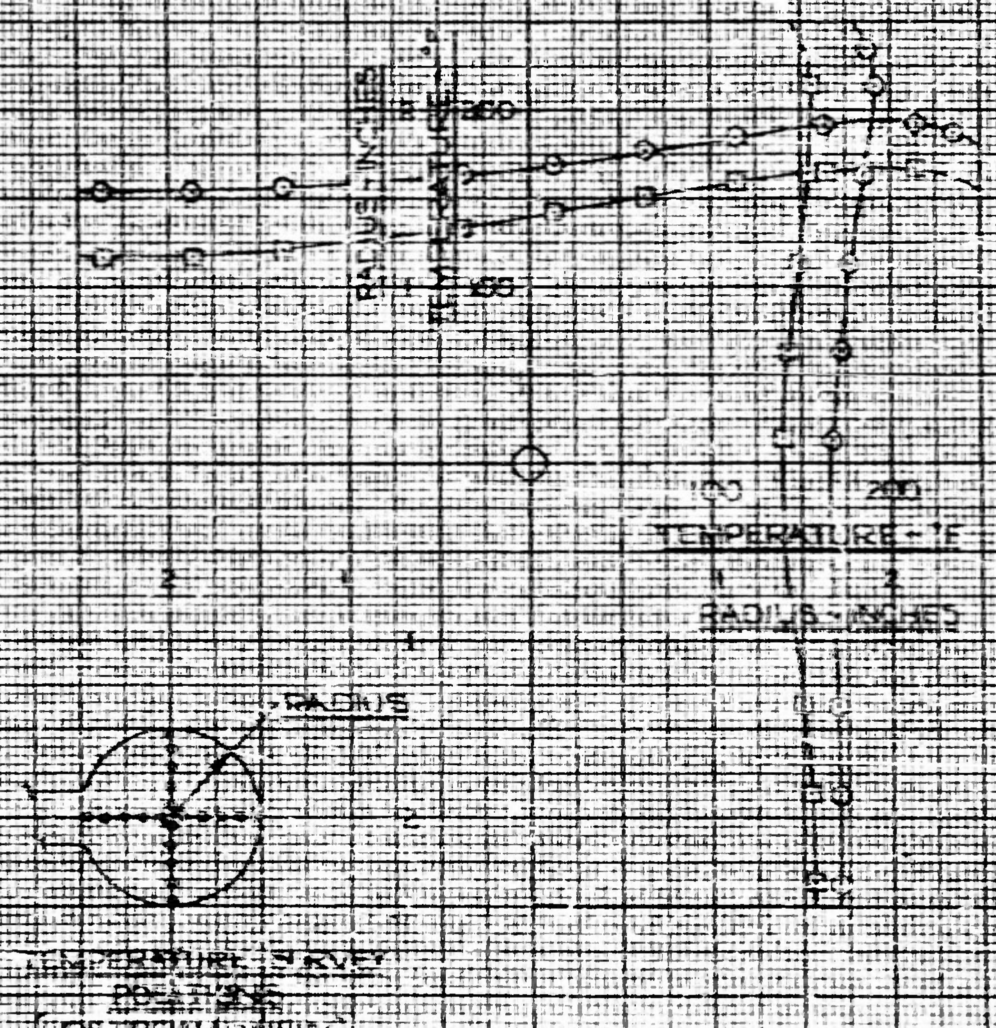


FIGURE 20 (CONT'D)

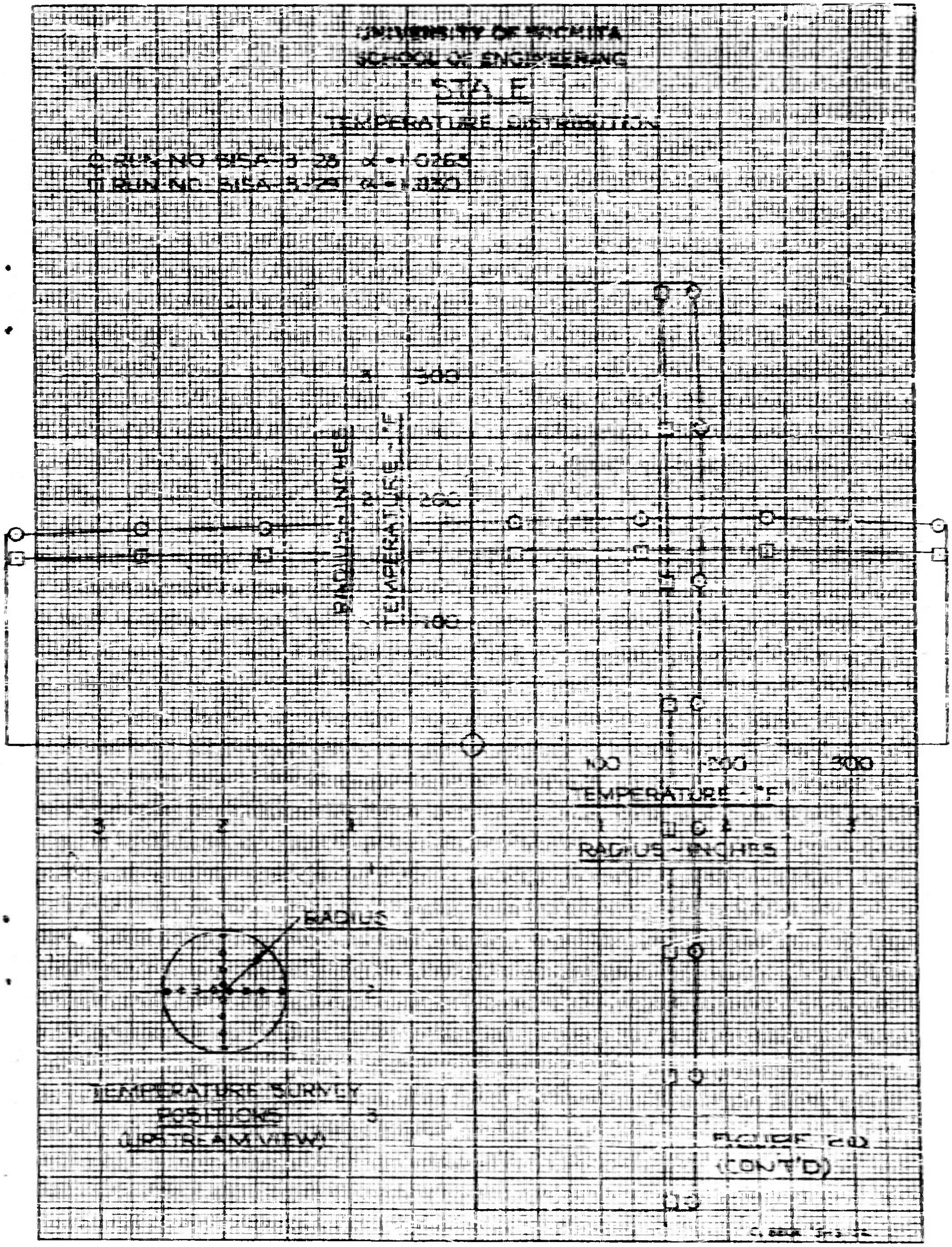


FIGURE 20
(CONT'D)

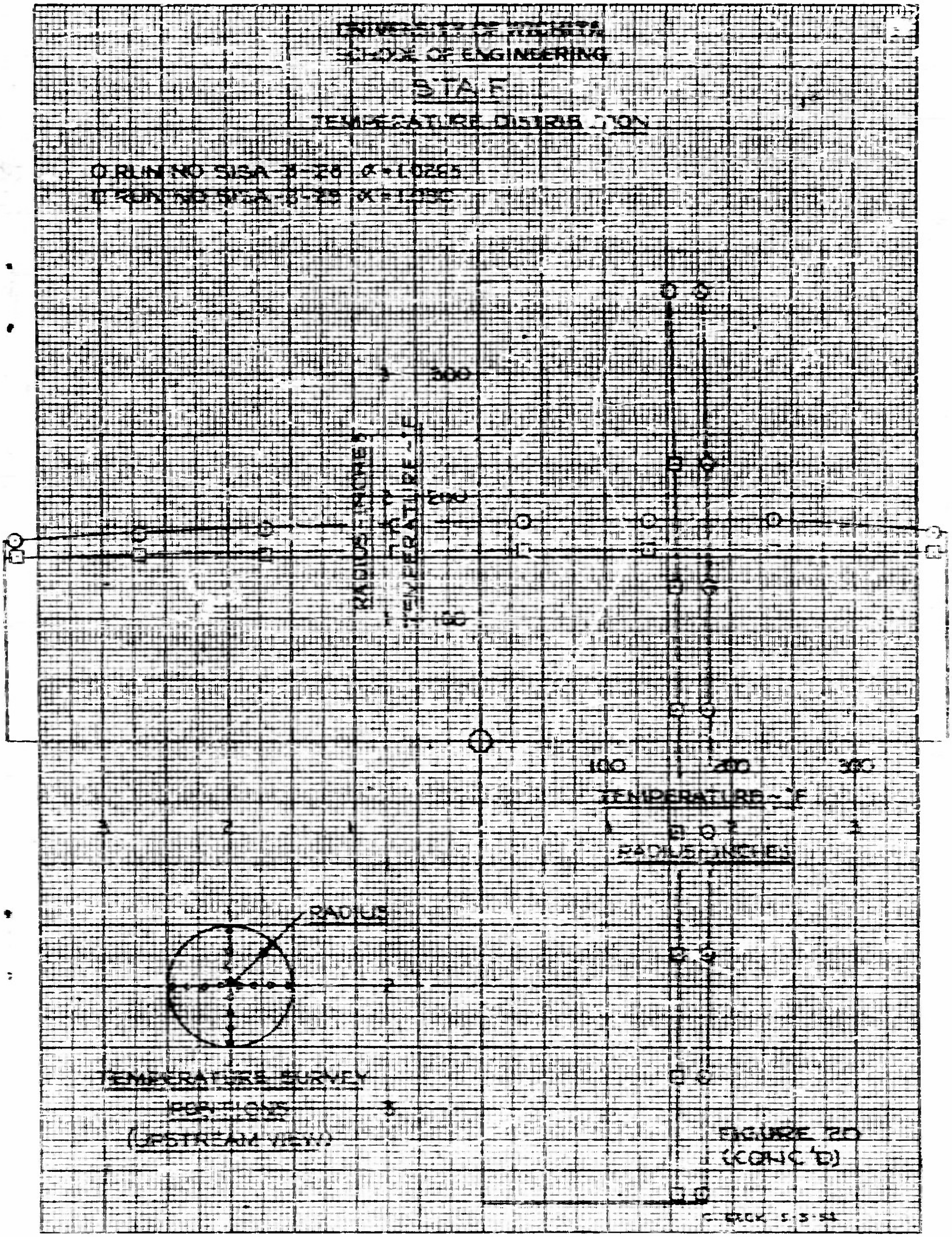


FIGURE 20
(CONC'D)

UWER No. 138
University of Wichita, School of Engineering
PERFORMANCE TEST OF A SIDE-INLET, STEAM-TO-AIR JET PUMP WITH AN INBOARD NOZZLE AND A TAPERED MIXING TUBE
A.M. Heinrich. May 1954. 76 pp., diagrs., photos., 2 refs.

A series of tests were conducted to determine the performance, the pressure and temperature distributions, and the nature of the flow in a side-inlet jet-pump with an inboard nozzle. This series of tests were performed on a pump having a conical mixing tube, a cascaded side-entrance throat, a suction duct, and a suction slot of constant width.

The effects of varying the primary jet pressure, the pump pressure ratio, and the cascades were determined. Pump pressure ratio was varied both with and without control of the suction-slot flow distribution. Flow direction in the suction duct between the slot and the throat was studied with the aid of wool tufts.

Performance curves are presented together with curves showing mixing-tube, cross-sectional distributions of temperature and total pressure taken at several survey stations. This report is the second in a series on side-inlet jet pumps with different taper ratio mixing tubes.

1.- Aerodynamics, Viscous Flow
2.- Jet Pumps
I.- Heinrich, A.M.
II.- UWER No. 138

UWER No. 138
University of Wichita, School of Engineering
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The effects of varying the primary jet pressure, the pump pressure ratio, and the cascades were determined. Pump pressure ratio was varied both with and without control of the suction-slot flow distribution. Flow direction in the suction duct between the slot and the throat was studied with the aid of wool tufts.

Performance curves are presented together with curves showing mixing-tube, cross-sectional distributions of temperature and total pressure taken at several survey stations. This report is the second in a series on side-inlet jet pumps with different taper ratio mixing tubes.

1.- Aerodynamics, Viscous Flow
2.- Jet Pumps
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II.- UWER No. 138

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University of Wichita, School of Engineering
PERFORMANCE TEST OF A SIDE-INLET, STEAM-TO-AIR JET PUMP WITH AN INBOARD NOZZLE AND A TAPERED MIXING TUBE
A.M. Heinrich. May 1954. 76 pp., diagrs., photos., 2 refs.

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